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Upper Pajaro Watershed Vegetated Buffer Strips
Carnadero Preserve
Santa Clara County

STATE WATER RESOURCES CONTROL BOARD
Clean Water Act Section 319(h) Nonpoint Source Implementation Grant
SWRCB Agreement Number 04-107-553-0
Awarded to
SANTA CLARA VALLEY WATER DISTRICT

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INTRODUCTION

The Santa Clara Valley Water District (SCVWD was awarded a Clean Water Act 319(h) Nonpoint Source Implementation grant in 2002. An agreement between the SCVWD and the State Water Resources Control Board (SWRCB) was subsequently executed in 2004 and amended in 2007. This report presents the scope of the project, a description of the approach and techniques used to implement the objectives of the project, a comprehensive reporting of the monitoring objective and a list of task deliverables as specified in the grant agreement.

1.1 Statement of Purpose

The Pajaro River and several tributaries have been listed by the State Water Resources Control Board as water quality impaired streams for parameters including nutrients and sediment. As a result, Total Maximum Daily Load (TMDL) for sediment and for nutrients are currently under development. The *"Pajaro River Watershed Water Quality Management Plan"(WQMP)* prepared for the Association of Bay Area Governments in June 1999 discusses possible causes for conditions which have resulted in these observed impairments.

"Fertilization of croplands in the Pajaro and Santa Clara Valleys have introduced elevated levels of nitrates, which is impairing both surface and groundwater resources in these areas…Cropland runoff is considered the major source of nutrients with the high potential to affect nutrient water quality." In terms of erosion and sedimentation, the plan states, "However, the most significant transport of soils from farmlands to surface waters occurs during the winter rainy season …access roads are not vegetated and are compacted, thus preventing maximal infiltration of rainfall."

Installation of vegetative buffer strips is consistent with recommended strategies of the (*WQMP)* and also with recommendations presented in *the "Monterey Bay National Marine Sanctuary Water Quality Protection Program's Action Plan for Agriculture and Rural Lands," October 1999 (MBNMSP).* The *WQMP* was prepared to identify, prioritize and recommend management strategies to mitigate nonpoint sources of pollution impairing surface water resources in the watershed. Section Four of this Plan, Watershed Water Quality Management Strategies, recommends several strategies to minimize water, soil, and sediment losses resultant of agricultural land use. One of the listed strategies is: "Use crop rotations, crop residue management, cover crops, conservation tillage, vegetative filter strips, grade stabilization structures, or sediment basins to minimize soil erosion…"

Though buffer strips associated with agricultural land use have not been actively employed in the Santa Clara Valley due to a shrinking agricultural presence and by elevated real estate costs, the southern portion of the County maintains a high percentage of agricultural land use and presents opportunities for this best management practice. The southern portion of the County, from Morgan Hill south to the Pajaro River, lies exclusively within the

Pajaro Watershed, thus any agricultural management measures implemented here will ultimately benefit the water quality of the Pajaro River.

Vegetative buffer strips have been shown to successfully remove pollutants and sediment from agricultural runoff before they enter surface water. This is why the United States Department of Agriculture's Natural Resource Conservation Service (USDA/NRCS) has actively promoted the installation of buffer strips to provide riparian buffer from agricultural and ranch lands. Despite the widely known and documented efficacy of vegetated buffer strips for the reduction of sediment and nitrogenous components of agricultural stormwater runoff, it is important to demonstrate the water quality benefits that can be experienced in this particular watershed.

This project specifically addresses the selection criteria for funding by implementing a recognized management measure that has been recommended in the Pajaro River Water Quality Management Plan and in the Plan for California's Nonpoint Source Pollution Control Program.

The goals of this project were to 1) install vegetated buffer strips composed primarily of grasses from existing stands within the watershed, 2) monitor for water quality and vegetation establishment 3) maintain vegetated buffer strip and 4) provide irrigation management information to the agricultural community.

1.2 Scope of Project

The purpose of the proposed project was to install vegetated buffer strips composed primarily of native perennial grasses along surface waters adjacent to actively cultivated land in order to provide buffering from nutrients and sediments. Under this project, approximately, 2.5 acres were planted into vegetated filter strips. It was anticipated that runoff would be monitored for nutrients and sediment for 3 years in attempt to assess the efficacy of the strips. The planted vegetation will be maintained by the SCVWD as demonstration of the water quality benefits provided by the installation of vegetated buffer strips and their use as a viable agricultural management measure.

The monitoring and maintenance of water quality parameters presents a major element of this project. The objective of the monitoring program was to assess the relative rate of vegetative establishment and surface coverage and to assess reductions in nutrient and sediment concentrations in runoff as related to buffer strip establishment. To this end, SCVWD contracted with the University of California, Santa Cruz to develop and administer a monitoring program. The work and report preparation was ultimately performed by staff of California State University at Monterey Bay. The monitoring program consisted of water sample collection from adjacent drainages and shallow soil sample collection from within, down gradient and up gradient of the planted areas. Included in the monitoring program was development of a Quality Assurance Project Plan (QAPP) and Monitoring Plan and development of a sample collection device design to be used for site conditions as presented on similar sites as experienced at the Carnadero Preserve during this project time frame. As described in Chapter 4, the monitoring program was adapted due to site conditions which did not render anticipated runoff flow.

The purpose of the irrigation management task was to prepare and distribute educational information to the agricultural community on irrigation management tools and their expected benefits. This relates to the objectives of vegetative buffer strip installation by encouraging more efficient use of irrigation water which would suggest a reduction in resultant overland flow from cropped fields and thus lead to a reduction in loadings of agricultural contaminants to surface water bodies.

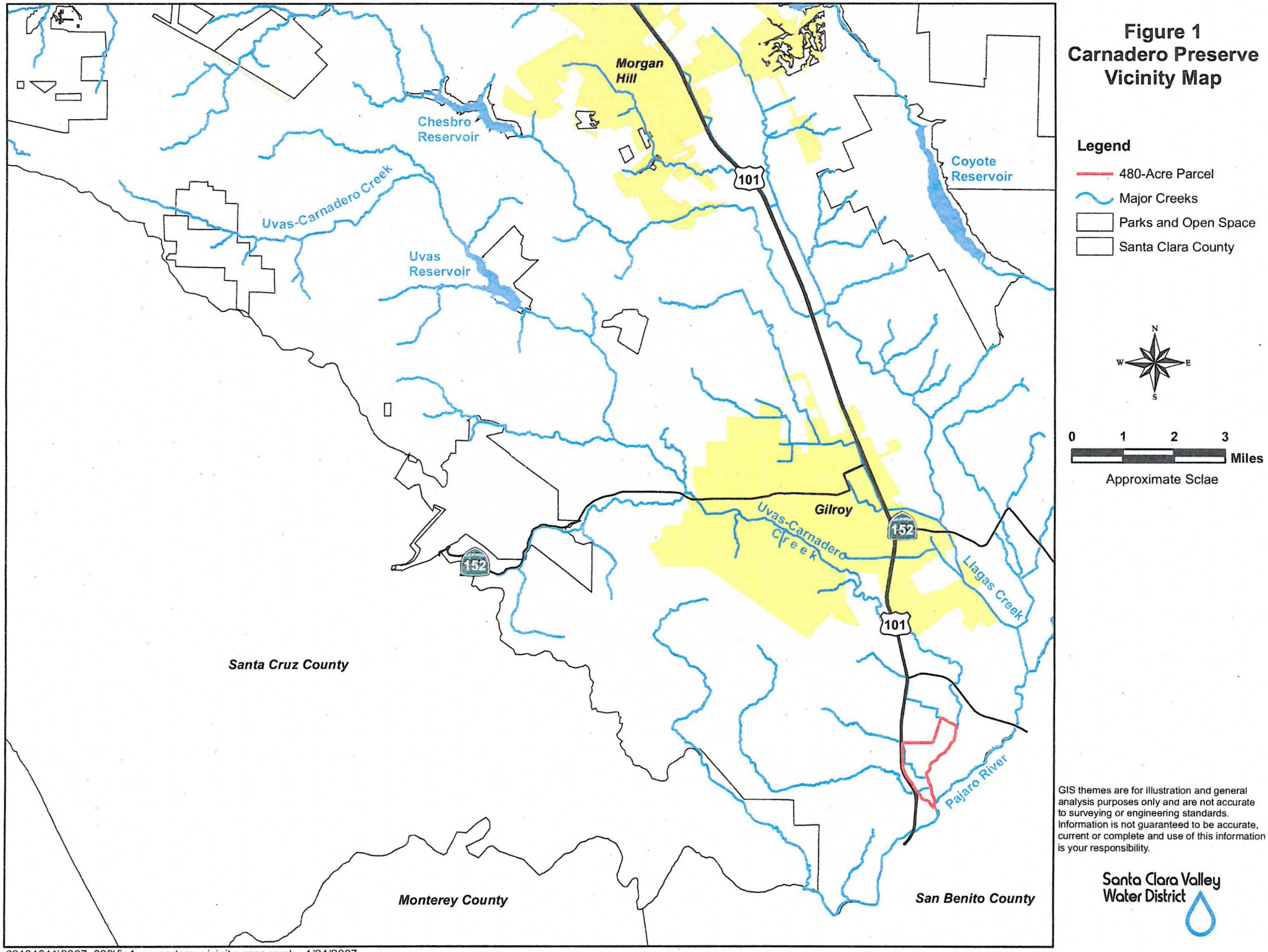
II. PROJECT INSTALLATION AND IMPLEMENTATION

Project Site

The project site is located at the Carnadero Preserve in southern Santa Clara County. (Figure 1). The SCVWD owns fee title to 198 acres within the preserve on portions of the property adjacent to and including water bodies. There are 3 creeks which run throught The property is bounded to the west by Highway 101, to the east by Uvas-Carnadero Creek, and to the south by the Pajaro River. In this vicinity, the Pajaro River defines the border between San Benito and Santa Clara Counties.

Two areas totaling approximately 2.5 acres were planted within the Preserve to function as vegetative filter strips. (Figure 2). Site A is located on the west bank of Tick Creek, downslope from an approximately 5 acre organically farmed field. (Figure 3). Site B is located between Uvas-Carnadero Creek to the east and Gavilan Drain to the west, just upgradient of the confluence of these two drainage channels. (Figure 4)

Figure 1
Carnadero Preserve Vicinity Map



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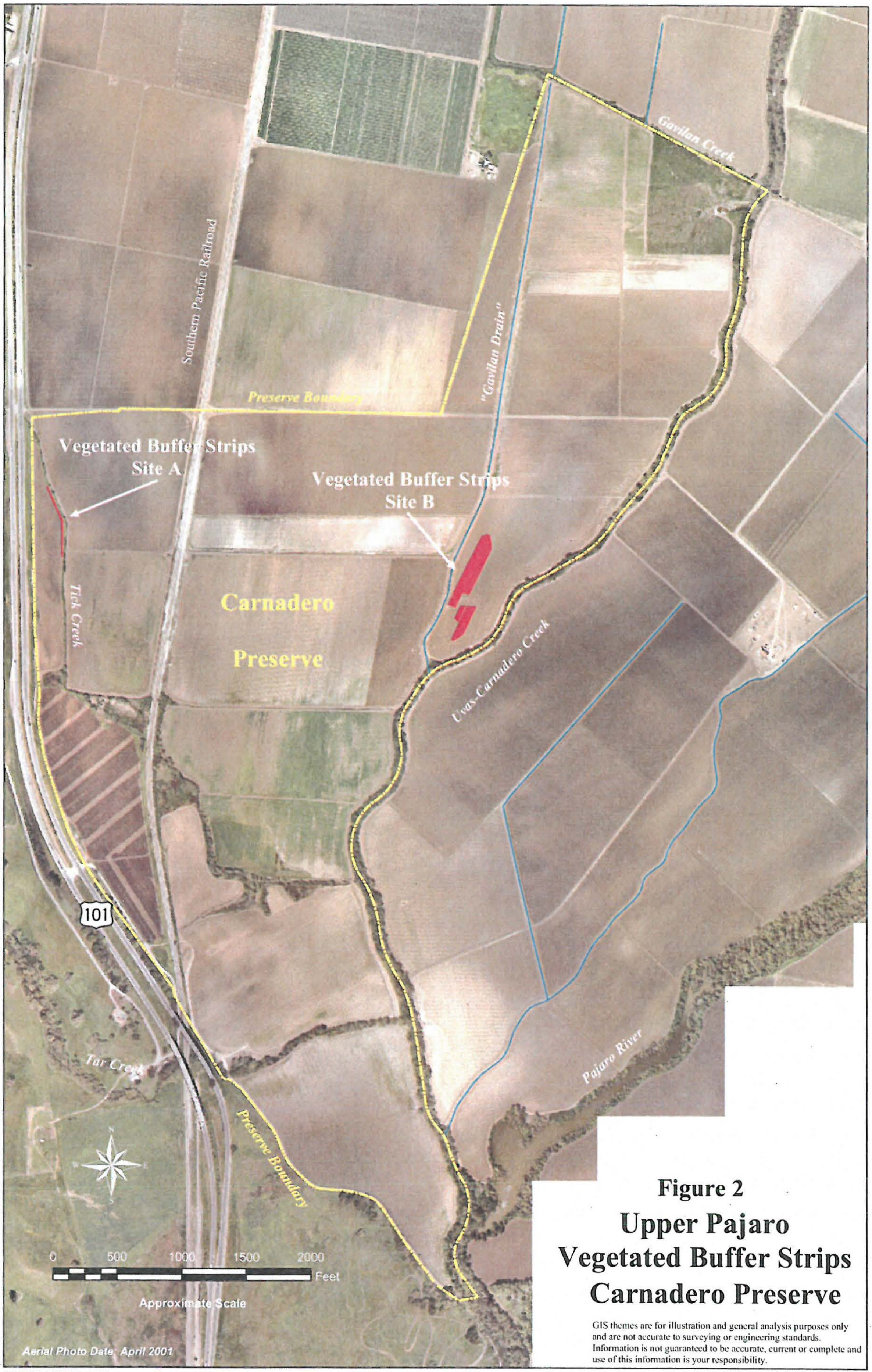

Figure 2

Upper Pajaro
Vegetated Buffer Strips
Carnadero Preserve

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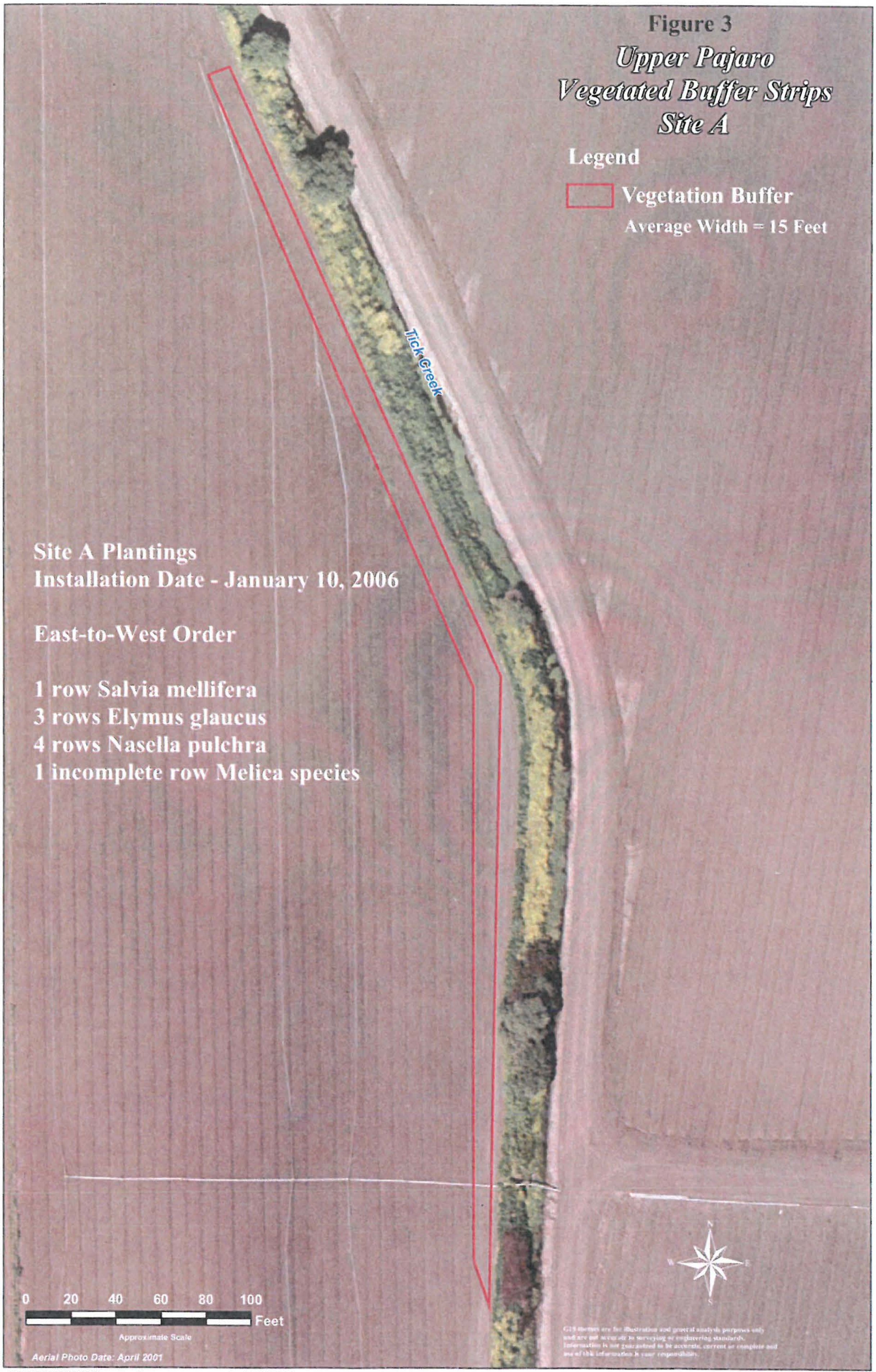

Figure 3

Upper Pajaro
Vegetated Buffer Strips
Site A

Legend

▭ **Vegetation Buffer**
Average Width = 15 Feet

Site A Plantings
Installation Date - January 10, 2006

East-to-West Order

1 row Salvia mellifera
3 rows Elymus glaucus
4 rows Nasella pulchra
1 incomplete row Melica species

Aerial Photo Date: April 2001

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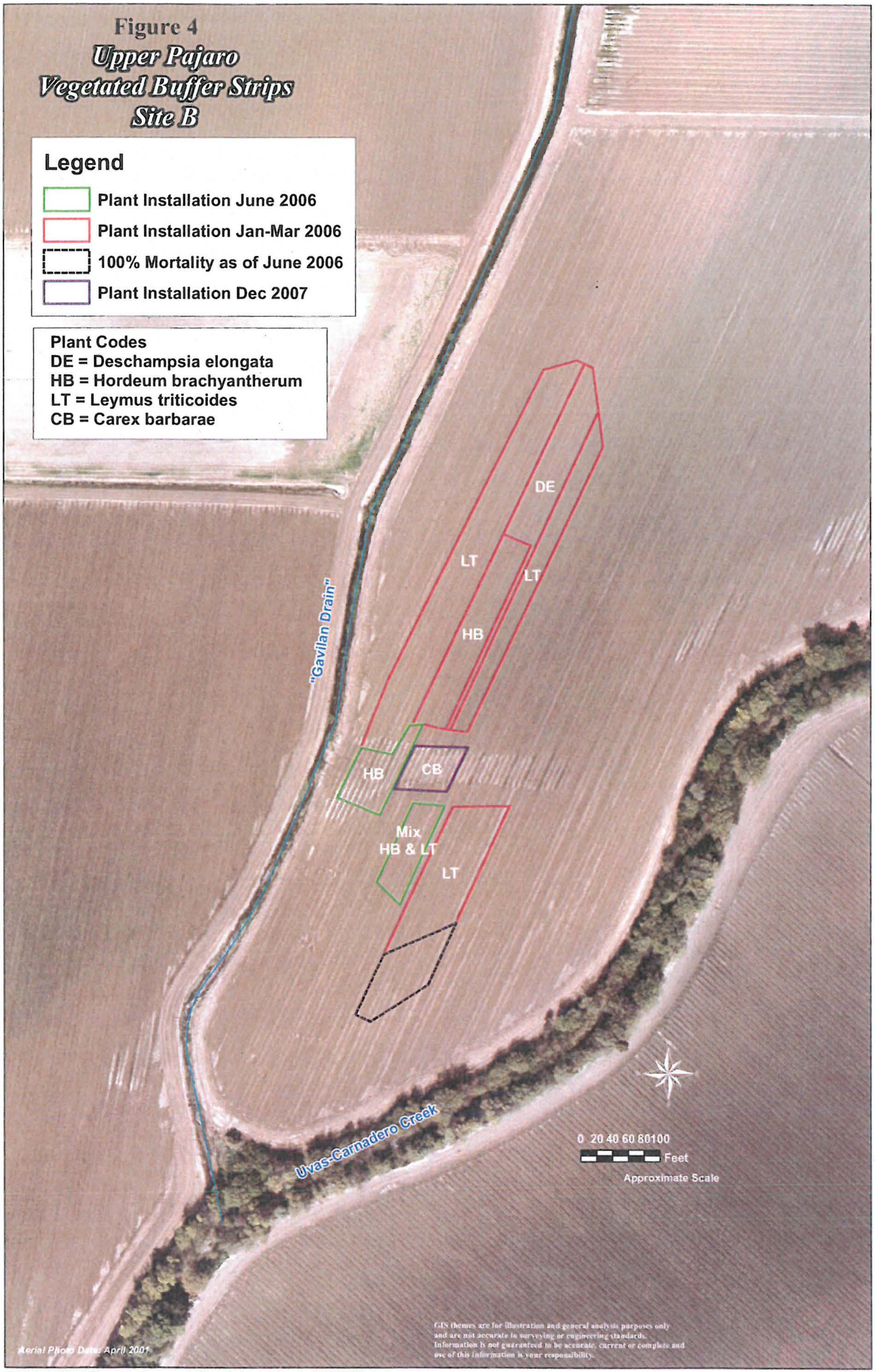

Figure 4
Upper Pajaro Vegetated Buffer Strips Site B

Legend
🟩 Plant Installation June 2006
🟥 Plant Installation Jan-Mar 2006
⬚ 100% Mortality as of June 2006
🟪 Plant Installation Dec 2007
Plant Codes
DE = Deschampsia elongata
HB = Hordeum brachyantherum
LT = Leymus triticoides
CB = Carex barbarae
DE
LT
LT
HB
HB
CB
Mix HB & LT
LT
"Gavilan Drain"
Uvas-Carnadero Creek
0 20 40 60 80100
Feet
Approximate Scale

Aerial Photo Date: April 2001

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Approach and Techniques

At the time of execution of the agreement between the SWRCB and the SCVWD, it was anticipated that property acquisition, either in easement or in fee title would be obtained for property on which to install the vegetative buffer strips. However, as the time frame of the grant schedule neared and plant materials were ready for installation, an agreement with a willing private property owner had not been obtained. Therefore, the SCVWD installed the vegetative strips on land that it had recently purchased for other purposes. For this reason, an amendment t to the agreement was executed to remove the property acquisition task, Task 4. The amendment as executed in October 2007 also transferred funds among task budgets to allow for additional planting to augment the areal extent of the buffers.

The buffer strips were predominately vegetated with native California perennial grasses and also with a native shrub (Salvia mellifera) and a native sedge (Carex barbarae) that had been collected and propagated from source plants within southern Santa Clara County. Propagation of local plant materials ensures that the genetic integrity of these species is maintained and increases the long-term viability of the vegetation effort. The established grass stand perpetuates the species and can serve as a seed source for future vegetation needs in the watershed and provide forage and nesting opportunities for wild life in addition to well acknowledged water quality benefits. All of the plants for this project were propagated from seed at a contract nursery for development in stubby tube containers (approximately 1.5 x 5 inch) and transplantation at the site.

The Site A buffer was planted in a strip approximately 15 feet wide and 500 feet long on the west bank of Tick Creek directly adjacent to existing creek bank shrubs. (Figure 3) Site A is well drained and adequately elevated from the creek bed so more drought resistant varieties were chosen. The plant palette consisted of the shurub, Salvia mellifera, and native perennial grasses, Elymus glaucus, Nasella pulchra, Melica californica and Melica imperfecta. The plants were installed in January 2006. The plants were watered in at the time of transplanting and received only small amounts of subsurface water from the upgradient planted field. The plants were self-sustaining after one year.

The Site B buffer was planted at various times due to portions of the site being inundated with storm flows. (Figure 4) Site B was planted with facultative wetland perennial grass species, Deschampsia elongata, Hordeum brachyantherum, and Leymus triticoides from January through March 2006 and in June 2006 as channel overflows receded and allowed safe access. In December 2007, Carex barbarae was transplanted from 4 inch containers and installed. These facultative wetland and wetland species were chosen do to the high groundwater table in this area and the frequency with which ponded water conditions are experienced.

An important element of development of and maintenance of vegetation is to ensure full and self-sustaining plant establishment. The most critical time frame for plant establishment is within the first two years when young, immature plants can be most easily out competed by aggressive annual weeds. Agricultural fields, particularly those that are routinely subjected to overland flows from over banking creek flows (like those experienced several times during the 2006 storm season from Uvas-Carnadero Creek), contain large volumes of weed species in the topsoil where seeds carried in storm water are additionally deposited. For this reason, weed removal was performed approximately every two months during the first 18 months following plant installation. Weeds were removed by hand and by mechanical methods.

An Irrigation Management brochure was designed, produced and distributed to provide comprehensive information on these irrigation management principles: 1). Irrigation system uniformity (i.e. distribution uniformity, DU) as the foundation for efficient irrigation; 2). Irrigation scheduling concerns the fundamental parameters of how much and when to irrigate in terms of efficient water use. The amount of needed irrigation is determined by the soil texture, the stress tolerance of the crop and the demands of the market; 3). Crop water use can be related to the fraction of ground covered by the crop and to the amount of water used by a reference crop (ETo), typically grass, that covers 100% of the ground and that is not short of water; 4). Efficient irrigation will maximize the crop produced per units of water and power consumed; and 5). Efficient irrigation will maximize fertilizer use efficiency. The 8.5 x 11 inch brochure was distributed to several agencies and organizations as indicated in the following table:

Organization/ Event	**Number of Brochures**
Coalition of Central Coast Farm Bureaus	550
Santa Clara and San Benito County Farm Bureaus	875
Small Acreage Workshop for Viticulturists 10/2005	40
Santa Clara County Winter Growers Meeting	100
Ecological Farming Association 2006 Conference	50
SCVWD Wells and Water Production Unit	100
SCVWD Water Use Efficiency Unit	100
Center for Agroecology and Sustainable Food Systems, UC Santa Cruz	75
Pajaro Valley Water Management Agency	300

III. MONITORING

Background on Nitrogen Dynamics and Vegetated Buffer Strips

The successful application of VBSs in California must consider two factors: buffer strip species composition and the role of the central coast's Mediterranean climate. California has few existing areas that can currently function as vegetative buffers since most stream and creek vegetation has been lost during agricultural development and flood prevention practices. Field crops are planted up to the edge of waterways, and growers have historically evaluated buffer vegetation as a nuisance and an economic loss. Thus, as a central part of the development of VBSs in California, these buffers areas will need to be restored, and species composition may play a critical role in their success.

In the case of nitrogen, aboveground species composition can influence soil N dynamics through a variety of mechanisms (Chantigny et al., 1996; Iritani and Arnold, 1959; Paul and Clark, 1996; Wedin and Tilman, 1990). Additionally, the effectiveness of some VBSs to retain N can depend on the composition of the plant species in the buffer (Daniels and Gilliam, 1996; Haycock and Pinay, 1993; Uusikamppa and Ylaranta, 1992; Young et al., 1980). Currently, no buffer species selection criteria exist for California. Much of central California is dominated by annual grasslands and precipitation is largely restricted to the winter months. Early in the rainy season, these annual grasslands have rapid changes in N availability (Davidson et al., 1990; Jackson et al., 1989; Schimel et al., 1989). After an initial increase in soil ammonium and nitrate, annual plants and microbes compete for mineral N, suggesting that annual grasslands may be effective as vegetative buffers to assimilate N from agricultural runoff. However, during the summer and fall, mineral N accumulates in the soil. With the first fall rain event, N can leach and contaminate ground and surface water before annual plants are established. Thus, VBSs composed entirely of annual grasses may not be effective at retaining N, and perennial, multi-species VBSs may be necessary for preventing seasonal nutrient leaching.

Objectives

This project installed vegetative buffer strips based on the documented success in other parts of the country and recommendation in both the Pajaro River Watershed Water Quality Management Plan and the Monterey Bay National Marine Sanctuary's Water Quality Protection Program's Action Plan for Agriculture and Rural Lands. The installation of buffer strips was not due to any observed excessive nutrient loads on this property; rather, they were installed as a pro-active measure to demonstrate the best management practice to the agricultural community and the regional community as a whole.

The objective of this study was to monitor water quality entering and exiting vegetative buffer strips planted between row crops and surface waters that drain into the Upper Pajaro River Watershed. We tested the buffer strips planted in the Carnadero Preserve to determine their effectiveness as a method to mitigate water quality impairment.

These data provide key information to determine the effectiveness of these buffer strips to improve water quality. In particular, these data have the potential to provide the scientific justification to implement this management practice in the region to reduce nitrogen, phosphorus, and/or sediment loading into the impaired surface waters of the Pajaro River.

The project proposed the following monitoring tasks:

(a) Collection of water samples during rainfall/irrigation events from the buffer strip site at a minimum of 3 times per year for a period of 2 years;
(b) Laboratory analysis of water samples for nitrate-N (nitrate-N (NO_3^-), + nitrite-N (NO_2^-)), ammonium-N (NH_4^+), and soluble reactive phosphorous (PO_4^{3-}) concentrations, total suspended solids, and total dissolved solids;
(c) Estimating erosion reduction based on the Revised Universal Soil Loss Equation.

After the project was funded, the site location was changed and we found that the site's weather and geohydrologic characteristics did not allow runoff samples to be collected, especially with the limited rainfall events in the 2006-7 water year. As will be discussed below, we altered the sampling objectives based on these characteristics and modified the monitoring tasks:

(a) Sample soils up- and down-gradient and within the buffer strips to assess soil available nitrogen (ammonium and nitrate) to determine if buffer strips improve the potential for nitrogen losses from row cropped areas to the surface waters on-site.
(b) Collect water samples along surface waters to determine if a nutrient gradient exists, where nitrate and ammonium concentrations increase through the site. These data may suggest that the buffers are limiting nitrogen loading into the surface waters adjacent to the buffer strips.

Field Methods

Carnadero Preserve is owned by the Santa Clara Valley Water District and near the confluence of Carnadero (Uvas) Creek and the Pajaro River adjacent to US 101. Most of the land is used for row crop production while two surface waters run through the parcel. Vegetative buffers were planted adjacent to each of these surface waters.

Two areas were planted with native vegetation between the row crops and surface waters (Figure 2. Carnadero Preserve map). Site A buffer was planted between row crops and Tick Creek, adjacent to Highway 101. The row crop slope is between 5-10% and has potential to generate runoff during heavy rainfall. Tick Creek is dry most of the summer and fall, but can have substantial flow during and immediately following storm events. However, runoff was never observed on this site during the project. The row crop area was approximately 10 meters in width and 130 meters in length. Downgradient of the row crops, a 2-3 meter wide buffer strip was planted.

Site B is located approximately 1000 meters east and is larger in size. It ranges between 10-20 meters in width and 300 meters in length, and has a low slope of 0.5-1%. The site receives Uvas Creek overflow water and is frequently inundated during rainy season. It is located immediately to the east of north -south running Gavilan Drain. Gavilan Drain contributes directly to Uvas-Carnadero Creek. Its hydrology is distinctly different, where the drain actively flows during the dry season, presumablely as a combination of irrigation return flows and creek water from the upper part of the watershed.

Table 1. Sampling summary for 2006-2007.

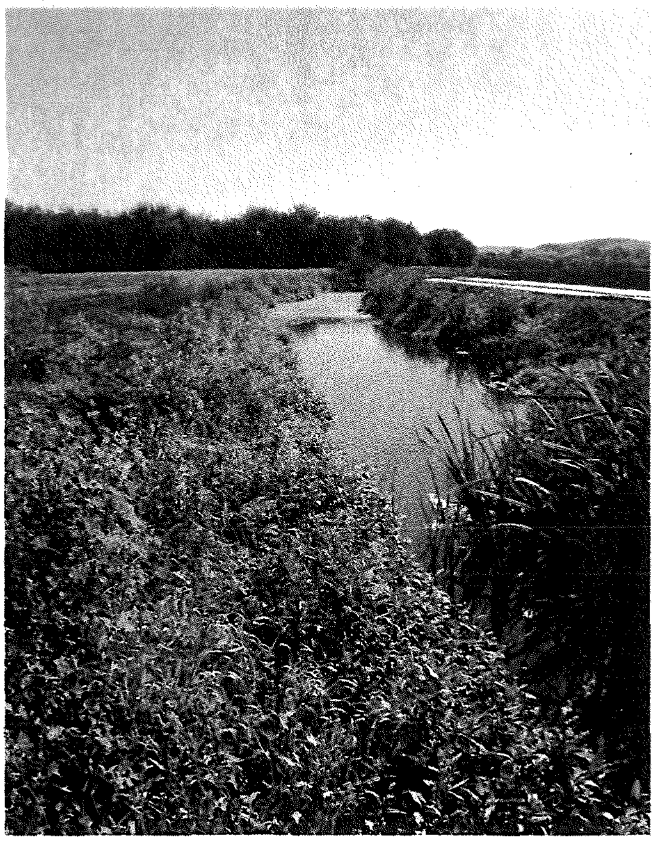
Date(s)	Location(s)	Sample Type
mm/dd/yyy	NA	NA
2/27/2006	Tick Creek	Water, grab
10/12/2006 - 10/17/2006	Tick Creek, Gavilan Drain	Soil, core
5/29/2007 - 5/31/2007	Tick Creek, Gavilan Drain	Soil, core
7/16/2007	Gavilan Drain	Water, grab
7/25/2007	Gavilan Drain	Water, grab

8/31/2007	Gavilan Drain	Water, grab

We initially intended to sample runoff generated by storm and irrigation events by collecting grab samples at the top and bottom of vegetated buffer strips during runoff events. Field staff maintained presence at the site between 2 and 5 hours during six storm events, where rainfall did not generate overland flow. We determined the site only generates runoff during very heavy rainfall events on saturated soils, which did not occur during the two year monitoring period. Site A was established on well drained soils and Site B becomes flooded when Carnadero Creek discharge is high. Although some creek water flows across Site B, the vegetated buffer strip is largely flooded, and this is not conducive to vegetated buffer strip filtering strategies.

Because runoff sampling was unsuccessful in the first year, we amended the QAPP to include soil sampling and analysis to determine how vegetated buffer strips influence available soil nitrogen—which is available to plant uptake and/or leaching and transport toward ground or surface waters. We also collected water samples at Tick Creek upstream and downstream of the buffer strip to determine if there is an ambient surface water quality change. These data were analyzed at University of California, Santa Cruz.

For soil sampling procedures, representative soil samples were collected from a depth profile of Site A and Site B during Fall 2006 and Spring 2007. Soil core samples were collected at transects perpendicular to the buffer strip from areas up-gradient and down-gradient of the treatment area, within the VBS, and at VBS borders (V. Appendix Figure 9). Each soil sample was collected at the same location at three different depths; 0-12 inches, 12-24 inches, and 24-36 inches. Homogenized soil cores were used for analysis from each sample location at the 3 corresponding depths. Soils were cored and samples put in plastic zip lock bags and returned to the laboratory at California State University Monterey Bay for processing in a cooler. In the laboratory, each sample was extracted with a 2 molar potassium chloride solution for 30 minutes and filtered through Whatman #1 filter paper and frozen until analyzed for ammonium and nitrate concentrations. Soil moisture was determined gravimetrically. Soil nutrient concentrations were analyzed with a four-way analysis of variance (ANOVA). The independent soil factors included Site (A or B), area (cropped area, buffer area, and creekside area), soil depth (0-12", 12-24", 24-36") and Date (two sampling dates, Fall 2006 and Spring 2007). We also included all the interaction terms. When the interaction terms were not significant, they were dropped from the model and the reduced model was reported. We considered factors to be significant in the p-value was below 0.05. If factors were found to be significant, we interpret that to mean that the factor has a significant effect on the dependent variable (nitrate or ammonium) in the test.



Water grab samples from Gavilan Drain were collected during summer and fall of 2007 at 10 sites upstream, adjacent, and downstream of the treatment area at Site B. Grab sample sites were selected at approximately 15-25 meter intervals along the reach. Sampling bottles were acid washed and samples were pre-rinsed three times with stream water prior to a collection from the entire water column. Collections began downstream of the treatment area and moved upstream over a reach of approximately 450 meters. Samples were immediately placed on ice and returned to the laboratory where they were filtered with Millipore 0.45micron filters. Samples were then frozen until analyzed.

Dissolved ammonium (NH_4^+), nitrate (NO_3^-), and soluble reactive phosphorous (PO_4^{3-}) concentrations were determined using a flow injection analyzer (Lachat Instruments, Inc. QuikChem 8500 Series). This multi-channel continuous flow analyzer injected a fixed volume of sample into a carrier stream and mixed it with reagents to form a color reaction. The color reaction was measured photometrically to determine the analyte concentration. The instrument had low detection limits that permitted small quantities of nutrients to be detected. A desktop computer maintained data acquisition and control of the machine. Data was stored on the computer hard drive after each sample was analyzed.

Inorganic ion concentrations were determined using an ion chromatograph (Dionex ICS-2000). A small volume of sample was injected and passed through an ion-exchange column. The anions were separated by their relative affinities to a low capacity, strongly basic anion exchanger. The anions were converted into their highly conductive acid forms by a strongly acidic suppressor exchanger. The acidic forms of the anions were detected by an electrical conductivity cell. Peak areas of each analyte were compared to those obtained from external calibration standards to generate concentration values for the samples. Results were monitored for instrument drift. Appropriate quality controls (QCs) were run to ensure quality data output. Data were stored on the computer hard drive after each sample was analyzed.

Each run of samples was analyzed with 3 QCs, at least 1 field duplicate and at least 1 spiked matrix sample. The spiked matrix sample was prepared as in the following example: A sample with an NO_3^--N, concentration of 2.6 mg/L was split into 5.0 mL sub-samples for spiking. A stock solution of 25mg N/L was added to one sub-sample in order to increase the nutrient concentration without significantly changing the volume. Adding 0.2mL of the stock solution increased the concentration by (0.2 mL) (25 mg/L) / (5.0 mL + 0.2 mL) = 0.96 mg/L. The new concentration was 0.96 mg/L + 2.6 mg/L = 3.56 mg N/L. Spikes included additions of nitrate, ammonium, and phosphate. Spiking levels were between 2 and 5 times the anticipated sample concentration.

All calibration standards, QCs, and samples were analyzed with 2 or 3 analytical replications. The range of nutrient concentrations accurately detected differences for each analytical method. If a sample contained concentrations above the calibration range, it was diluted and reanalyzed.

Precision measures how closely repeated measurements of a given sample agree with each other. The precision of the nutrient concentration measurements were evaluated by replicate analysis of every sample. In addition, at 10% of the stream visits replicate samples were taken. Precision was measured by calculating the relative percent difference (RPD), used only when two replicates were analyzed, or the relative standard deviation (RSD), used when two or more replicates were analyzed. The RPD or RSD must be less than 25% for a sample to be accepted. If the RPD or RSD was greater than 10%, the sample was shaken to ensure it was well mixed, or re-filtered to remove interfering particles, and reanalyzed

Table 2. Relative percent deviation by analyte for 2007 Site B water grab samples.

Date dd/mm/yyyy	Ammonium RPD Avg. %	Ortho-P RPD Avg. %	Nitrate RPD Avg. %
7/16/2007	4.28	4.13	0.69
7/25/2007	2.97	2.85	1.13
8/31/2007	4.16	2.41	1.49

Accuracy (bias) measures the conformity between measured and true values. To determine the accuracy of nutrient data, 3 quality control (QC) references of known nutrient concentrations were analyzed both at the beginning and at the end of every batch of field samples. The reference values must be within 80-120% of the true concentrations for the batch of samples to be accepted.

Table 3. Accuracy reporting for 2007 Site B water grab samples.

Analysis Date	Reference	Accuracy	Reference	Accuracy	Reference	Accuracy
	Ammonium	Ammonium	Ortho-P	Ortho-P	Nitrate	Nitrate
mm/dd/yyyy	mg/L	%	mg/L	%	mg/L	%
8/30/2007	3	97.73	1.5	97.47	15	NA
8/30/2007	1.5	104.60	0.75	99.60	7.5	NA
8/30/2007	0.1	93.35	0.1	96.63	0.5	NA
8/31/2007	3	NA	1.5	NA	15	96.67
8/31/2007	1.5	NA	0.75	NA	7.5	94.27
8/31/2007	0.1	NA	0.1	NA	0.5	94.90
10/4/2007	3	98.14	1.5	96.73	15	92.15
10/4/2007	1.5	100.14	0.75	97.08	7.5	91.34
10/4/2007	0.1	89.85	0.1	94.55	0.5	86.74

Representativeness describes the degree to which the results represent the samples, and the samples represent the media from which it was taken. For this project, a representative data set was ensured by homogenizing three soil subsamples at each depth plus sampling from at least four transects. Along each transect, at least two samples were up-gradient, down-gradient, and within the buffer strip.

Table 4. Relative percent difference or standard deviation comparing duplicates to reference values.

Sample ID	Type	Method	RPD / RSD	Ammonium	Nitrate
Site, Transect, Depth (ft.)	NA	NA	NA	%	%
Gavilan Drain, A4, 0-12	KCL Soil Extract	QuikChem	RPD	6.5854	40.6015
Gavilan Drain A6 12-24	KCL Soil Extract	QuikChem	RPD	7.5840	2.8037
Gavilan Drain E5 12-24	KCL Soil Extract	QuikChem	RSD	0.3590	4.3224

Travel blanks were also analyzed to determine whether environmental contamination of nutrients occurs during the sampling procedure. Travel blanks were prepared by filling a sample bottle with KCl in the lab, transporting it into the field, and opening it briefly at a random sampling site and analyzing it the same way as other samples.

Completeness is the percentage of samples collected that were analyzed. The completeness goal for this project was 90%. Failure to meet this goal may result from the field assistant's inability to sample at some sites because of site access or soil preparation that limits access.

Table 5. Completeness for all samples, 2006-2007.

Date(s)	Location(s)	Sample Type	Collected	Analyzed	Completeness
mm/dd/yyy	NA	NA	#	#	%
2/27/2006	Tick Creek	Water, grab	2	2	100
10/12/2006 - 10/17/2006	Tick Creek, Gavilan Drain	Soil, core	180	180	100
5/29/2007 - 5/31/2007	Tick Creek, Gavilan Drain	Soil, core	231	219	94
7/16/2007	Gavilan Drain	Water, grab	10	10	100
7/25/2007	Gavilan Drain	Water, grab	10	10	100
8/31/2007	Gavilan Drain	Water, grab	10	10	100

It is important to note that available soil nitrogen is highly variable because of the heterogeneity of soils relative to air and water matrices. Therefore, in spite of goals for precision and accuracy in the laboratory, field variability will outstrip laboratory variability

Proposed Sampling Device Design

As part of the initial scope of the project, we reviewed literature and the design for an automated surface runoff device, Low Impact Flow Event sampler. After the new site was selected, it was determined that insufficient runoff would prevent this device from functioning. Nevertheless, we include the design background as a resource for future projects.

Surface water runoff across properly functioning buffer strips does not flow in concentrated channels. Instead, runoff may be characterized as sheet flow, which is extremely difficult to sample. Additionally, runoff is extremely variable in time and space, since runoff can vary on the order of minutes and inches along a sampling frame. Thus, providing an instrument that can automatically trigger sampling is extremely important. Secondly, because buffer strips are designed to limit surface runoff, overland flow will be unevenly distributed and difficult to capture. By creating a "wide" area of sampling, water samples may be able to integrate variable microtopography to collect a representative sheet flow sample.

The low impact flow event (LIFE) sampler, designed by Sheridan, Lowrance, and Henry (1996) was formulated to provide a composite overland flow sample at a low cost. The LIFE sampler has been implemented as an overland flow sampler for studies on field runoff, conservation and riparian buffer area effectiveness, and small watershed runoff (Franklin et al. 2001, Bonilla et al. 2006, Durham 2003). The sampler was conceived in an effort to perform unattended sampling of surface runoff while being small enough to minimize widespread disruption of natural flow, ground surface, and vegetative cover (Sheridan et al. 1996).

To collect composite overland flow data and discrete nutrient samples, the collection capabilities of a LIFE sampler can be integrated with an ISCO automated system's event triggered sampling. The integration is designed to be effective in low overland flow field conditions by utilizing the LIFE sampler's collection area to concentrate flow from a 30.5 cm (12 in) wide area into a collection container. The collection container provides a volume of sample that may not be achievable by traditional grab sampling techniques. The collection container also serves as a sample reservoir for the ISCO sampling system, allowing an uptake of the minimum of 20mL sample volume necessary for nutrient analysis. ISCO samples are kept on ice within the ISCO unit and collected for laboratory nutrient analysis.

Surface runoff empties into a metal splitter area measuring 30.5 cm wide by 30.5 cm (12 in) long, with a 19 cm (7.5 in) spout at the end that pours into a collection chamber. The collection mouth of the splitter acts as a funnel for surface water flow. Inside the divisor, the collection area splits into 10 portions by metal dividers, with one portion directed toward the collection container (Figure 1). This effectively allows for a 10x sample, reducing total composite sample volume in high overland flow areas. Two samplers are linked in a chain to provide a 100x sample (Sheridan et al. 1996).

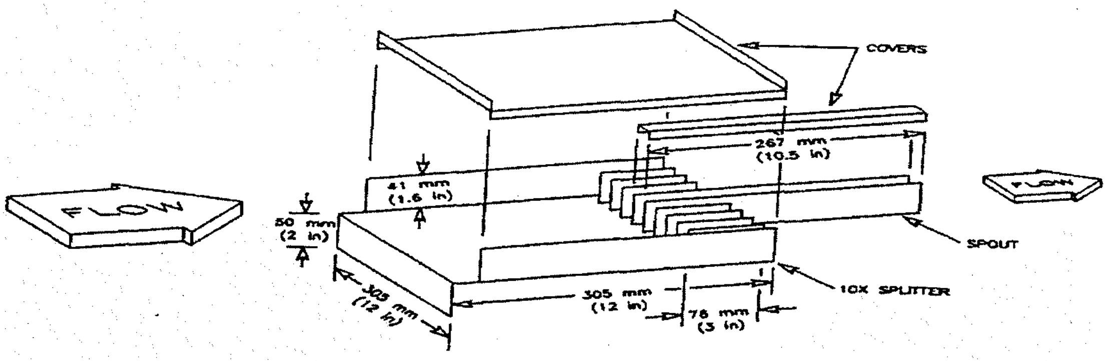


Figure 1–10X sample splitter assembly.

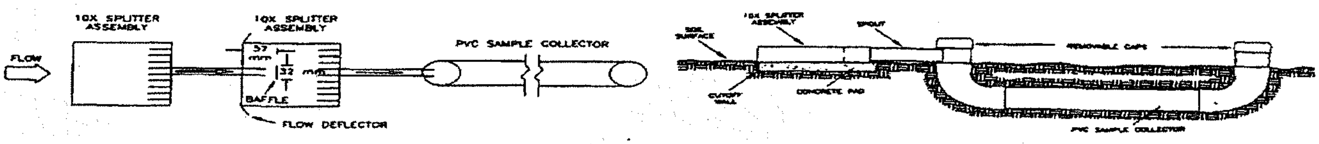


Figure 2–Plan view of 100X sampler installation.

Figure 3–Cross-section of 10X sampler installation.

Figure 1. Splitter assembly diagram and installation (Sheridan et al. 1996)

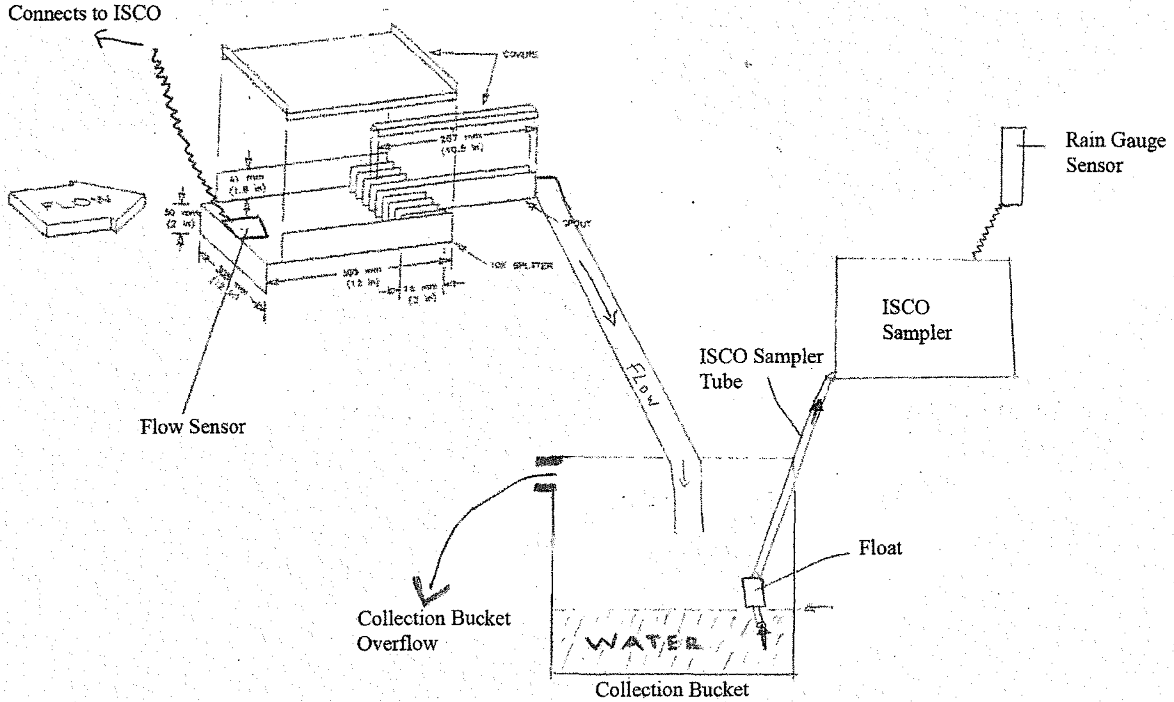
It costs approximately $125 for construction materials per sampler. Installation is simple; the splitter is installed on a concrete landscape pad to place it flush with the ground surface, the 10x collector is linked to the collection chamber, and the collection chamber is buried or placed downhill of the splitter. When the collection chamber fills, sample volume is measured and sediment sample is collected.

To integrate the LIFE sampler with the ISCO, an ISCO collection tube is placed upon a float to sit at or below the water surface within the LIFE sampler collection chamber. A rain gauge or flow trigger can be programmed with threshold limit parameters to initialize ISCO sampling. This will ensure that ISCO collections are triggered during storm or heavy irrigation events and when a minimum sample volume is available within the collection chamber. An overflow lip is incorporated into the collection chamber should overland flow exceed estimates of collection capacity (Figure 2). In addition, field runoff estimates can be used to program ISCO sampling rates, and to determine an effective collection chamber size for the site.

To sample buffer strips a minimum of two of the integrated systems must be installed; one above the strip and one below. After installation, the system would require minimal maintenance. A single person can attend to a site to remove debris clogs, empty collection chambers, check ISCO operation, collect and restock ISCO bottles, and restock ice for nutrient samples. Since the system would be installed in advance of storm events, sampling the beginning and the end of an event is assured more so than the use of a field team. In comparison to the workforce required to maintain an on-call field sampling crew to collect samples and monitor weather and overland flow conditions, the LIFE/ISCO sampler integration poses potential as an effective alternative to accomplish similar sampling objectives.

However, the LIFE sampler is not appropriate for all overland flow contexts. The weather must be able to create overland flow by creating saturated soils in the area of interest. Second, the discharge must be able to flow unimpeded, i.e. without debris blocking the manifold or plugging any of the water transport pipes or tubes. Areas with a great deal of organic matter, such as leaves, might prove to be problematic. Third, selecting the size the collection bucket takes experience, as a bucket too small may not collect enough water for a sample while a bucket too large might increase the runoff residence time so that the sample does not accurately represent runoff water quality. Finally, characterizing sediment capture with this device is not appropriate because it is impossible to keep sediment in suspension for the ISCO sampler to collect a representative sample.

Figure 2. LIFE/ISCO integration.



Results and Discussion

Water Quality

The U.S. Environmental Protection Agency and the California State Water Resources Control Board have determined water must be below 10 mg N/L (ppm) as nitrate to be safe for drinking. However, in general, concentrations above 1 mg N/L are considered elevated in the region based on comparisons between non-impacted waterways. Currently, there are no regulatory standards for ionized ammonium, but the Regional Water Quality Control Board has determined that the 0.025 mg N/L or higher of unionized ammonia is toxic. Because measuring unionized ammonia in the field is rarely done, its concentration is calculated from the ammonium concentration, water temperature and pH. There is no regulatory standard for soluble reactive phosphorus; however, the Regional Water Quality Control Board has used 0.12 mg/L as a non-regulatory criterion.

Surface runoff did not occur during the study period. Therefore, we could not directly determine the water quality changes of water moving across the buffer strips. However, in many agricultural fields, non-vegetated areas adjacent to waterways provide a context for water improvement in the stream. Water samples were collected at various times during the study to characterize the water quality entering Carnadero Preserve and determine if the agricultural field and buffer areas were influencing water quality in the two waterways, Tick Creek and Gavilan Drain.

Tick Creek (Site A) is not a perennial stream and was dry for the majority of 2007. This severely limited our ability to sample, and allowed for one sampling period during the study (Table 6). As water enters the property near top of the planted buffer strip at Site A, nitrate concentrations are already above background levels, suggesting an off-site source of nitrogen loading. There is a slight increase as water flows adjacent to the buffer but due to the limited sampling, any conclusion based on these data would be highly uncertain.

The relationship between short-term water quality variability, surface water and ground water interactions, and in-stream nitrogen removal and release was outside the scope of this study. For example, these data may or may not represent the same parcel of water. Because we revised our initial sampling plan, the relationship between the buffer and the creek can not be determined. Thus we provide these data to note that further work along this reach is warranted.

Table 6. Nutrient concentrations in water grab samples at Site A.

Location	Area	Date	NH3-N	P	NO3&NO2-N
NA	NA	mm/dd/yyyy	mg/L	mg/L	mg/L
Tick Creek	Above Buffer Strip	2/27/2006	0.0086	0.0384	4.0650
Tick Creek	Below Buffer Strip	2/27/2006	0.0018	0.0273	4.3100

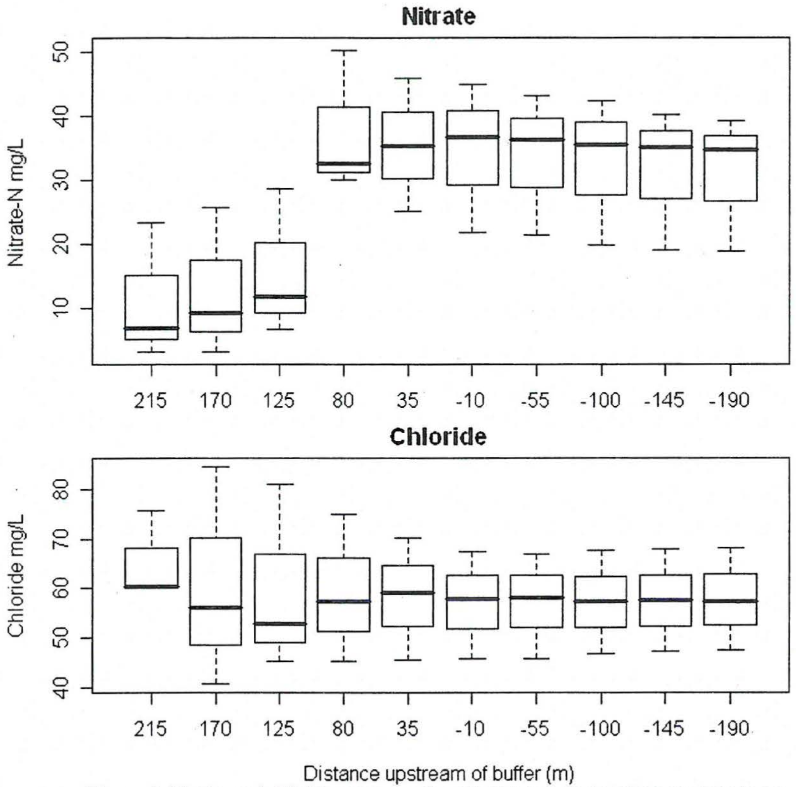


Figure 4. Nitrate and chloride concentrations in Gavilan Drain upstream vegetated buffer. Grab samples were collected Fall 2007.

Nitrate (NO_3^-) concentrations in water grab samples from the Gavilan Drain (Site B) are relatively high compared to what might be considered natural levels and the drinking water standard. This is typical of nitrate concentrations draining row crop agriculture with high water tables. The average nitrate concentration in the waterway during summer of 2007 was 27.5 mg N/L. In particular, the nitrate concentrations increase dramatically eighty meters upstream of the buffer. Nitrate and chloride concentrations are not constant within the drain (Figure 4). Chloride concentrations are included because chloride can be used as a conservative tracer of groundwater interactions since it is not subject to biological assimilation. Nitrate concentrations increased dramatically about 80 meters upstream of the buffer zone and appear to decline as water moves adjacent the planted buffer area. The chloride concentrations appear to be more variable upstream of the buffer zone, which suggest additional waters entering the buffer that have varying source mixtures (e.g. groundwater, agricultural return flow, and natural sources). Because the chloride concentrations remain constant downstream of the planted buffer areas, there does not appear to be a major source of additional water to the creek, i.e. agricultural runoff.

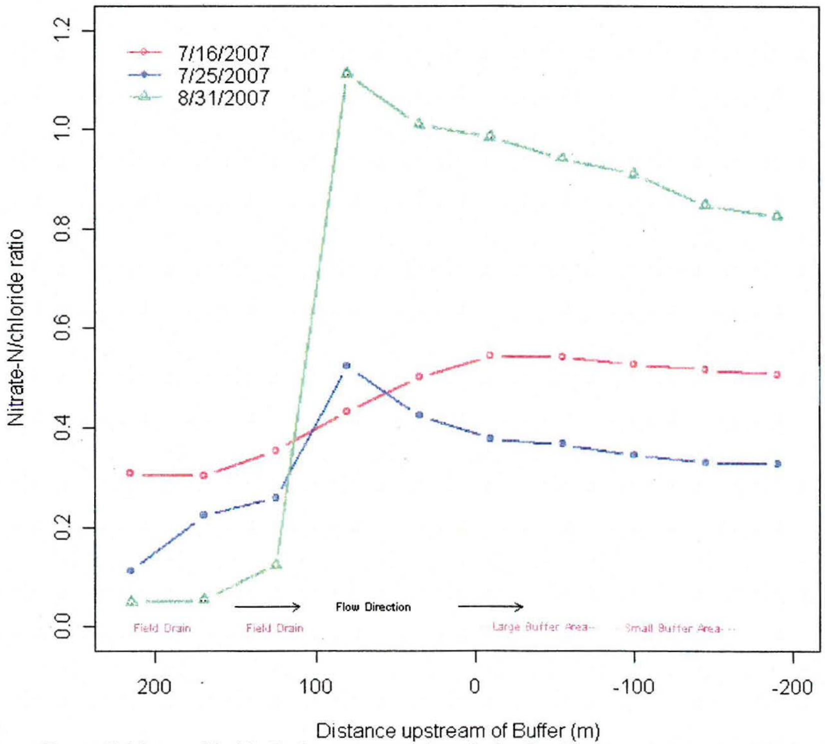


Figure 5. Nitrate:chloride Ratios concentrations in Gavilan Drain upstream vegetated buffer. Grab samples were collected Fall 2007.

By using nitrate relative to chloride (NO_3^-:Cl-) concentrations as a ratio, we can determine the relative importance of nitrogen in terms of biogeochemical processes. Where the nitrate concentrations increased dramatically, the nitrate:chloride ratio similarly increased. However, as the water moved downstream of the buffer area, nitrate:chloride concentrations declined (Figure 5).

Upon inspection of the farm, we found the increase in nitrate and nitrate:chloride was due to field drains that discharge into the creek. More importantly, the nitrate:chloride concentrations declined as the water passed the buffer areas, suggesting that no new nitrogen is added to the stream and that nitrate is removed from the surface waters biologically. The mechanism for this removal is unknown. However, it is likely due to biological denitrification.

Nitrite concentrations often increase where nitrification (conversion from ammonium (NH_4^+) to nitrate (NO_3^-)) and denitrification (conversion of nitrate (NO_3^-) to nitrous oxide (N_2O) and dinitrogen gas (N_2) is active. We found nitrite concentrations do increase in waterways next to the buffer area, which suggests nitrogen removal is stimulated by in-stream removal processes, most likely denitrification (Figure 6)

To summarize, we believe planted areas do improve water quality in the creek in the summer because additional nitrogen does not appear to be entering from the buffer areas. We suggest additional sampling during the growing season when the water table is higher to determine how consistent the results are. Additionally, the stream itself appears to actively remove upstream sources of nitrogen possibly through denitrification. Although the overall decline is modest, it appears that nitrogen removal occurs within the buffer portion of the waterway.

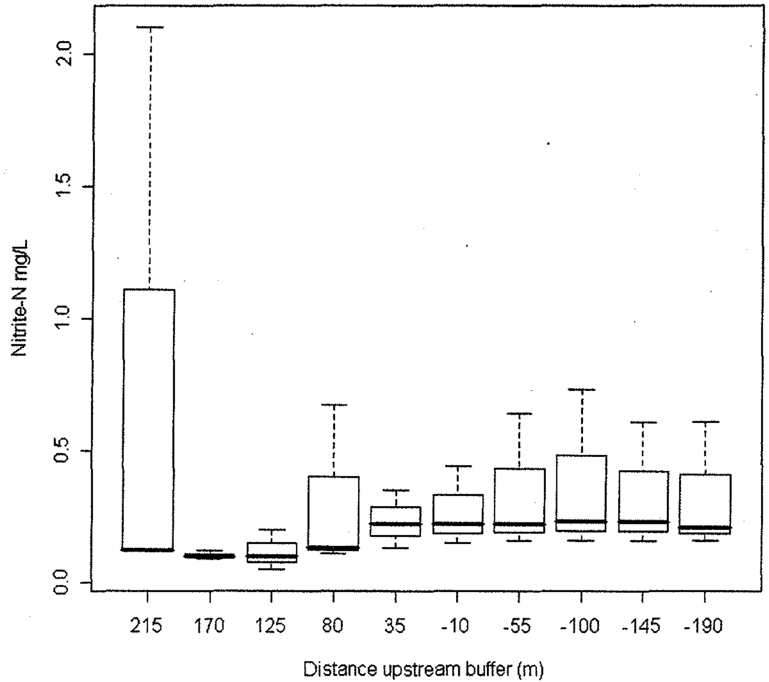


Figure 6. Nitrite concentrations in Gavilan Drain upstream vegetated buffer. Grab samples were collected Fall 2007.

Soil Nutrients

Available soil nitrogen concentrations are subject to numerous factors including soil temperature, rainfall, root uptake, microbial remineralization, leaching, soil organic matter, and exogenous inputs. In general, microbial activity using soil organic matter as a source of energy can release ammonium into the soil, depending on the quality of the soil organic matter (e.g. carbon:nitrogen ratio, secondary compounds, etc). Ammonium is considered the first inorganic nitrogen product of organic matter breakdown by microbial activity. Average ammonium (NH_4^+) concentrations in the soil over 2006-7 sampling dates are higher at the Tick Creek site than the Gavilan Drain site. This is probably due to the second year growing season when the grower did not grow row crops near the waterway adjacent to the Site B near Gavilan Drain (Figure 7). Comparing average ammonium concentrations during Fall 2006 and Spring 2007 for Site A and B combined, concentrations are higher in the fall than during the late spring. In general, ammonium concentrations increase in the Mediterranean climate during the summer as plant uptake declines due to unfavorable water conditions but microbes continue to mineralize nitrogen, albeit at a lower rate due to low soil moisture. Differences between the buffer, creekside, and cropped areas and ammonium availability do not demonstrate a significant difference. This is not surprising since nitrification, the conversion from ammonium to nitrate, is energetically favorable and nitrate is usually a better measure of available nitrogen in soils along the Central Coast region.

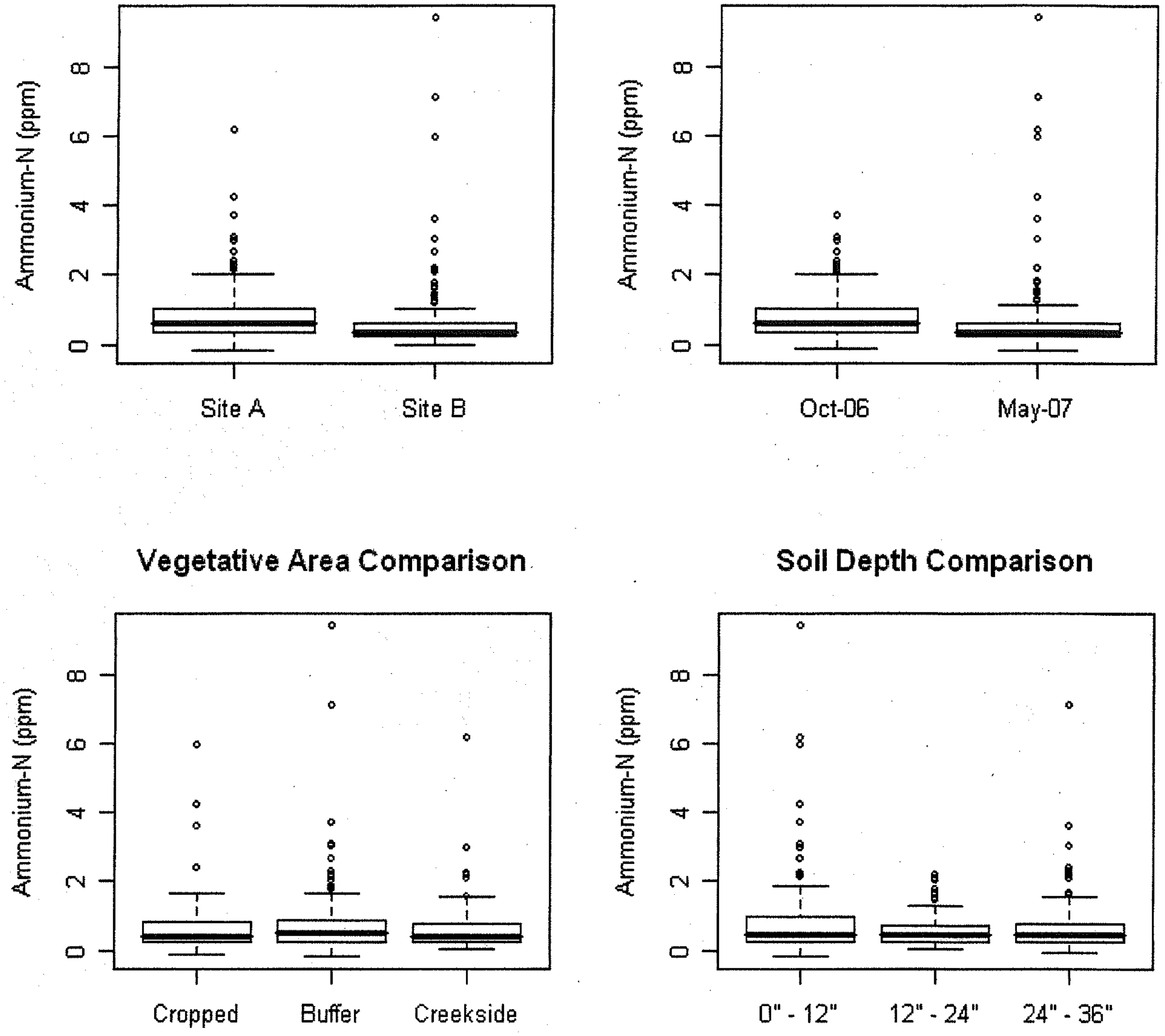
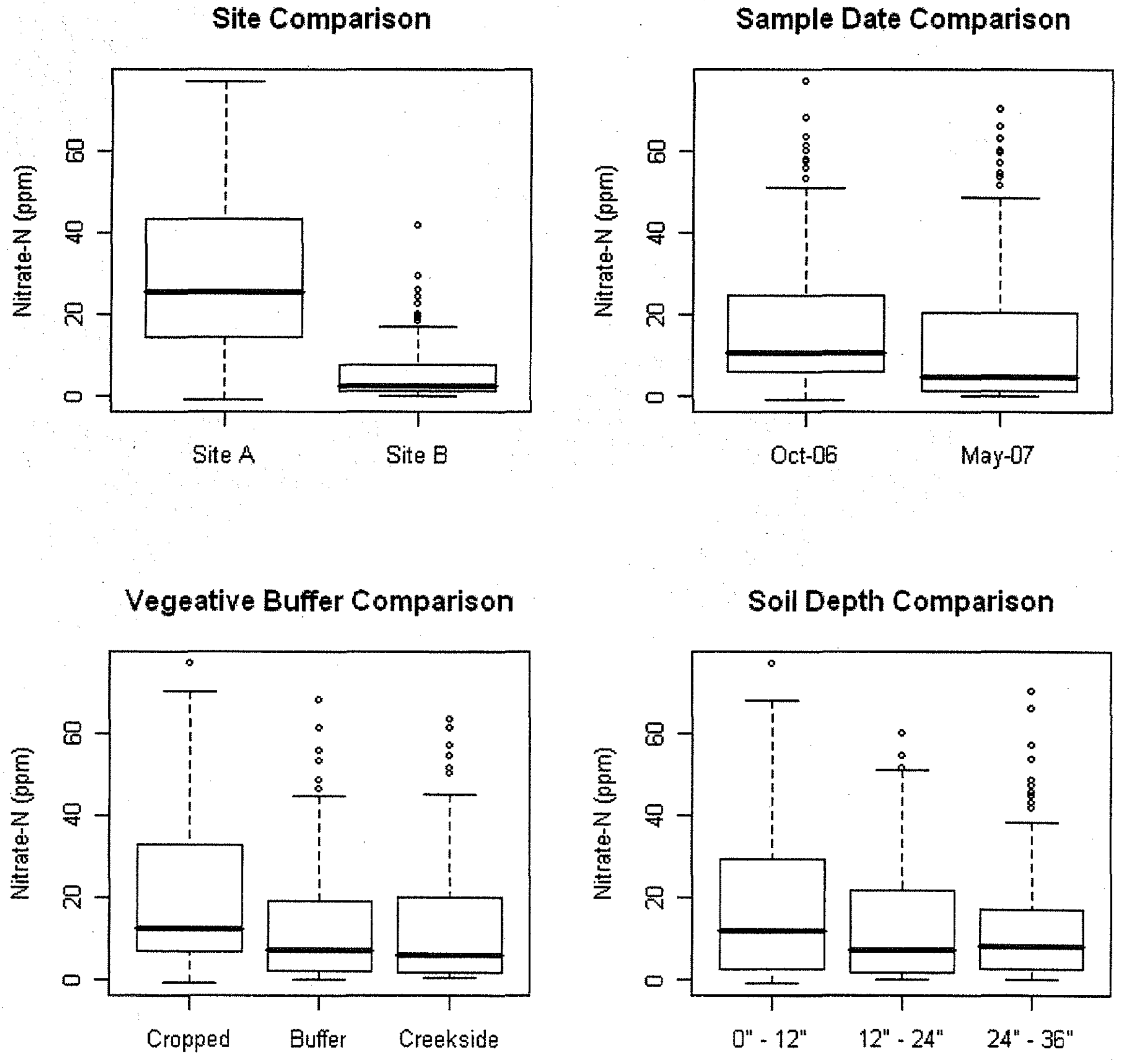


Figure 7. Boxplot of Available Soil Ammonium (ppm)

In contrast to soil ammonium concentrations, soil nitrate (NO_3^-) concentrations varied dramatically when comparing Site A to Site B. In particular, nitrate concentration variation also varied within the sites, i.e. in the cropped, buffer, and creekside areas. Nitrate concentrations were significantly different, based on site, sampling depth, area sampling date, and the interaction between several factors (Table 7). As implied above, soil nitrate can be an important indicator of soil processes in the Mediterranean climate as demonstrated by Figure 8. As water moves through soil pore spaces, it moves through the vadose zone toward the water table. An increase in vadose zone nitrate suggests nitrate had the potential to reach the water table and adjacent surface waters.

Table 7. Four-way Analysis of Variance to test the role of site location, within site area, soil depth, and sampling date on soil nitrate (NO-^{3}) (2006-7). Df=degrees of freedom, SS=sum of squares, MS= mean sum of squares, Pr = probability of a significant effect.

	Df	SS	MS	F value	Pr(>F)
Site	1	326	326	438	< 0.001 ***
Area	2	19.2	9.6	12.9	< 0.001 ***
Depth	2	21.4	10.7	14.5	< 0.001 ***
Date	1	79.6	79.6	106.8	< 0.001 ***
Depth:Date	2	18.2	9.1	12.4	< 0.001 ***
Area:Date	2	4.7	2.31	3.2	0.042 *
Area:Transect	33	51.6	1.6	2.1	< 0.001 ***
Site:Area:Transect	31	42.7	1.4	1.89	< 0.01 **
Residuals	327	239	0.73		


Site Comparison

Sample Date Comparison

Vegeative Buffer Comparison

Soil Depth Comparison

2006-7
average
nitrate

Figure 8. Boxplot of Available Soil Nitrate (ppm)

concentrations in the soil were higher at Site A than Site B. This was due to the fact that Site

A remained in production for the entire period, while Site B was put in a cover crop during year 2 (Figure 8). Comparisons of nitrate concentrations for Fall 2006 were higher than Spring 2007; this is considered typical for soils in a Mediterranean climate.

The last two panels of Figure 8 demonstrate the functionality of the buffer strips. Cropped area nitrate concentrations are the highest with concentrations declining in the buffer area, and creekside concentrations being the lowest. The nitrate concentrations also tend to decrease with depth, with the highest concentrations at the surface and lowest at 24-36 inches deep. Assuming that vadose zone water plays an active role in transport of nitrate toward groundwater and the creek, these data suggest that the risk of nitrate contamination of groundwater and surface waters declines with the addition of vegetative buffer strips.

The effectiveness of the VBSs must be determined by the water quality leaving buffer strips and entering waterways. In this study, this was best done by sampling groundwater in the unsaturated and saturated zone. The vadose zone water in the VBS was derived from a combination of subsurface flow from the row crops and surface runoff that left the row crops and infiltrated into the VBS soils. As the subsurface water moved through the buffer, nitrate concentrations declined, suggesting nitrate attenuation. However, the potential existence of preferential for flow paths limits the strength of this conclusion.

We believe future research in the application of buffer strips should explicitly test species for their capacity to improve water quality. Remnant populations of native grasslands have been found in areas protected from disturbance, e.g. railroad right-of-ways (Clements, 1934) and farm borders (Bugg et al., 1997), and thus the establishment and maintenance of native grasses may occur in some parts of California. Resource agencies may be able to combine the goal to restore grasslands with native perennials, while using them to improve water quality. However, species composition in newly established buffer strips is likely to change for several years during establishment. The species composition of grasslands can change dramatically with fertilizer or mulch additions (Heady, 1958; Hull and Muller, 1976). Research has found that when N fertilizer has been added to serpentine grassland soils the species composition shifts toward non-native species, with the possible extinction of rare species (Huenneke et al., 1990). Thus, the selection of species for vegetative buffers may continually be undermined by invading species. Although this project did not explicitly test the role of species composition in buffer areas to improve water quality, it demonstrated the feasibility of using specific native plant species.

Conclusion

The success of VBSs to improve water quality depends upon surface and ground water flow paths as potential pollutant transport mechanisms. Furthermore, at any given site, the implemented methods to measure buffer effectiveness will vary. In general, buffer strips are considered effective when overland runoff reaches the buffer in diffuse or non-concentrated flows. Since no concentrated overland flow occurred across the buffers at the Carnadero Preserve during the study period, this might suggest that the buffers were effective. However, a comprehensive picture of the nutrient and sediment reductions in overland flow was limited by relatively low rainfall years and the lack of *any* overland flow across the newly established buffers. Therefore, we have no direct evidence to support the effectiveness of VBSs to reduce polluted runoff. However, by modifying the sampling procedures, we were able to make indirect observations to evaluate the VBSs. Our monitoring project indicates that VBSs have the potential to reduce nitrate concentrations in the vadose zone. Assuming that the VBS vadose zone water contributes to surface and groundwater, buffer strips may serve as an effective practice to reduce nutrient loading to Pajaro River.

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IV. PROJECT TASK DELIVERABLES

The table below presents deliverables by task as specified in the agreement between the SWRCB and the SCVWD. At the time of execution of the agreement between the SWRCB and the SCVWD, it was anticipated that property acquisition, either in easement or in fee title would be obtained for property on which to install the vegetative buffer strips. However, as the time frame of the grant schedule neared and plant materials were ready for installation, an agreement with a willing private property owner had not been obtained. Therefore, the SCVWD installed the vegetative strips on land that it had recently purchased for other purposes. For this reason, an amendment t to the agreement was executed to remove the property acquisition task, Task 4. The amendment as executed in October 2007 also transferred funds among task budgets to allow for additional planting to augment the areal extent of the buffers.

TASK	DELIVERABLE	Date Submitted
1. Project Management		mm/dd/yy
	1.2 Quarterly Progress Report	9/16/05
		2/8/06
		6/19/06
		10/5/06
		03/23/07
		7/11/07
		10/10/07
	1.5 Contract Summary Form	2/22/06
	1.7 Contractor Documentation/ Solicitation Documentation	N/A
	1.8 Project Survey Form	
2. CEQANEPA/Permits		
	2.1 CEQA/NEPA Documents	11/9/2005
	2.2 Permits	N/A
3. QAPP and Monitoring Plan		
	3.1 Quality assurance project plan	1st draft 9/15/05 final 3/14/06 amendment 1/4/07
	3.2 Approved Monitoring Plan	Included in QAPP
5. Project Plans and Specifications		
	5.2 Project drawings and specifications	Draft 2/9/06 As builts as of 10-4-06 As builts at project completion included in final report
	5.4 Copies of Approval Letters and Permits	N/A

TASK	DELIVERABLE	Date Submitted
6. Plant Propagation and Installation		
	6.5 Pre- and Post Digital Photos of Project Site	2/9/06
7. Monitoring and Maintenance		
	7.2 Water Quality Analytical Data	In draft report
	7.3 Photo Monitoring	2/9/06 6/11/07
8. Education and Outreach		
	8.3 Irrigation Management Brochure	9/23/05
9. Draft and Final Reports		
	9.1 Draft Report	12/07/07
	9.2 Final Report	12/31/07

V. APPENDIX- Water Quality Analytical Data

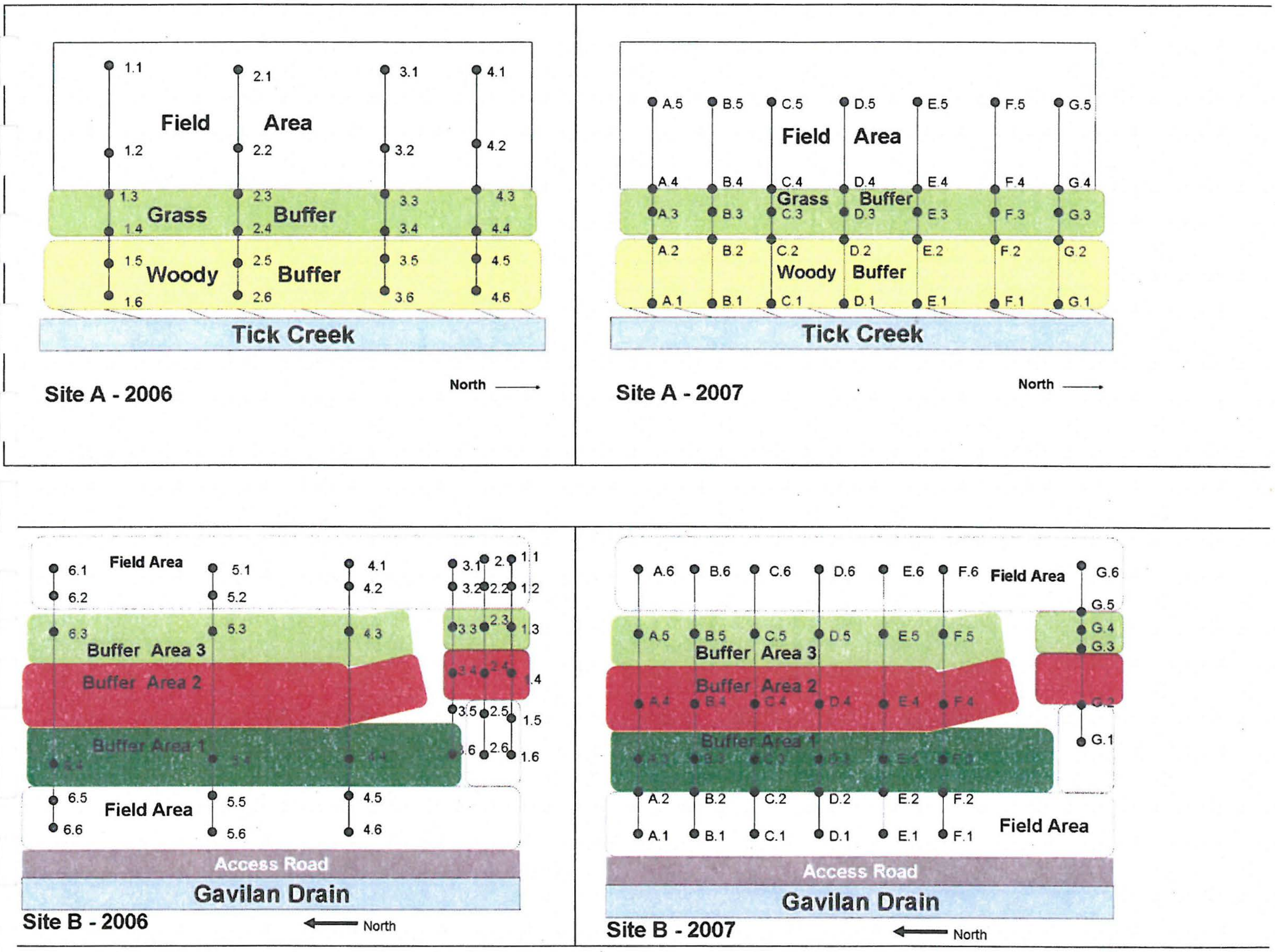

Figure 9 – Soil sampling map for 2006 & 2007, Sites A &B showing approximate sample locations. Not drawn to scale.

Table 8 – Nutrient measurements for 2007 Gavilan Drain water samples.

Date	Measurement	Analyte	Analyte	Analyte
m/dd/yyyy	NA	NH_4^+-N (mg/L)	PO_4^{3-} (mg/L)	NO_3^- & NO_2^- - N (mg/L)
7/16/2007	Average Standard Deviation Difference (Hi-Lo)	0.011611 0.005245	0.01199 0.01044	31.16 4.99 13.65
7/25/2007	Average Standard Deviation Difference (Hi-Lo)	0.01979 0.006461	0.05300 0.03572	17.08 6.40 20.31
8/31/2007	Average	0.09424	0.1324	32.81

	Standard Deviation	0.07592	0.0854	20.98
	Difference (Hi-Lo)			49.28

Table 9 – Inorganic ion measurements for 2007 Gavilan Drain water samples.

Date	Measurement	Analyte	Analyte	Analyte	Analyte	Analyte	Analyte
m/dd/yyy	NA	F^- (mg/L)	Cl^- (mg/L)	NO_2^--N (mg/L)	SO_4^{2-} (mg/L)	Br^- (mg/L)	NO_3^--N (mg/L)
7/16/2007	Average	0.3478	72.44	0.1364	259.13	0.2946	32.34
	Standard Deviation	0.02697	6.32	0.0250	13.20	0.0241	4.79
	Difference (Hi-Lo)		17.47				
7/25/2007	Average	0.3190	55.04	0.1709	161.09	0.4032	18.35
	Standard Deviation	0.05220	6.50	0.0662	24.65	0.0881	7.19
	Difference (Hi-Lo)		19.39				
8/31/2007	Average	0.4453	49.28	0.6467	217.05	0.2822	31.87
	Standard Deviation	0.1318	5.28	0.5503	3.85	0.0622	19.36
	Difference (Hi-Lo)		15.11				

Table 10. Nutrient concentrations for water grab samples from Gavilan Drain (Site B) 2007.

Location	Distance	Date	NH3-N	P	NO3&NO2-N
NA	m	mm/dd/yyyy	mg/L	mg/L	mg/L
Gavilan Drain 1	45	7/16/2007	0.0072	0.0066	34.0000
Gavilan Drain 2	90	7/16/2007	0.0086	0.0051	34.3250
Gavilan Drain 3	135	7/16/2007	0.0096	0.0047	34.4000
Gavilan Drain 4	180	7/16/2007	0.0156	0.0055	36.0000
Gavilan Drain 5	225	7/16/2007	0.0219	0.0052	35.6750
Gavilan Drain 6	270	7/16/2007	0.0051	0.0065	33.0750
Gavilan Drain 7	315	7/16/2007	0.0060	0.0084	30.6500
Gavilan Drain 8	360	7/16/2007	0.0131	0.0175	27.3500
Gavilan Drain 9	405	7/16/2007	0.0152	0.0267	24.1000
Gavilan Drain 10	450	7/16/2007	0.0140	0.0338	22.0250
Gavilan Drain 1	45	7/25/2007	0.0148	0.0168	18.1500
Gavilan Drain 2	90	7/25/2007	0.0297	0.0179	18.1750
Gavilan Drain 3	135	7/25/2007	0.0179	0.0257	18.3250
Gavilan Drain 4	180	7/25/2007	0.0163	0.0327	19.7500
Gavilan Drain 5	225	7/25/2007	0.0115	0.0196	20.4500
Gavilan Drain 6	270	7/25/2007	0.0216	0.0589	22.4000
Gavilan Drain 7	315	7/25/2007	0.0231	0.0975	27.2500
Gavilan Drain 8	360	7/25/2007	0.0220	0.0594	10.8250
Gavilan Drain 9	405	7/25/2007	0.0293	0.1060	8.5750
Gavilan Drain 10	450	7/25/2007	0.0120	0.0955	6.9450
Gavilan Drain 1	45	8/31/2007	0.1660	0.1025	28.9500
Gavilan Drain 2	90	8/31/2007	0.0116	0.0887	43.6000
Gavilan Drain 3	135	8/31/2007	0.0755	0.0702	45.7000
Gavilan Drain 4	180	8/31/2007	0.0108	0.0705	46.7000
Gavilan Drain 5	225	8/31/2007	0.0929	0.1270	49.0000
Gavilan Drain 6	270	8/31/2007	0.0796	0.1240	49.3000
Gavilan Drain 7	315	8/31/2007	0.0634	0.1440	53.0000
Gavilan Drain 8	360	8/31/2007	0.1235	0.0325	7.7750

Gavilan Drain 9	405	8/31/2007	0.2645	0.2865	4.0350
Gavilan Drain 10	450	8/31/2007	0.0547	0.2780	0.0247

Table 11. Inorganic ion concentrations for water grab samples from Gavilan Drain (Site B) 2007.

Location	Distance	Date	F	Cl	NO2-N	SO4	Br	NO3-N
Gavilan Drain 1	45	7/16/2007	0.37	68.17	0.16	250.5	0.3	34.61
Gavilan Drain 2	90	7/16/2007	0.37	67.8	0.16	250.2	0.3	35.06
Gavilan Drain 3	135	7/16/2007	0.37	67.54	0.16	250.6	0.31	35.59
Gavilan Drain 4	180	7/16/2007	0.37	66.99	0.16	249.58	0.3	36.24
Gavilan Drain 5	225	7/16/2007	0.37	67.43	0.15	250.95	0.32	36.69
Gavilan Drain 6	270	7/16/2007	0.36	70.24	0.13	257.78	0.31	35.22
Gavilan Drain 7	315	7/16/2007	0.35	74.85	0.11	268.16	0.3	32.46
Gavilan Drain 8	360	7/16/2007	0.32	81.1	0.1	280.83	0.28	28.64
Gavilan Drain 9	405	7/16/2007	0.3	84.47	0.1	282.56	0.27	25.61
Gavilan Drain 10	450	7/16/2007	0.3	75.81	0.12	250.16	0.24	23.3
Gavilan Drain 1	45	7/25/2007	0.33	57.33	0.21	166.82	0.43	18.84
Gavilan Drain 2	90	7/25/2007	0.36	57.45	0.23	164.64	0.44	19.01
Gavilan Drain 3	135	7/25/2007	0.34	57.37	0.23	166.97	0.43	19.8
Gavilan Drain 4	180	7/25/2007	0.34	58.01	0.22	170.77	0.45	21.33
Gavilan Drain 5	225	7/25/2007	0.34	57.78	0.22	172.59	0.45	21.8
Gavilan Drain 6	270	7/25/2007	0.36	59.05	0.22	183.78	0.47	25.03
Gavilan Drain 7	315	7/25/2007	0.37	57.26	0.13	194.71	0.51	29.99
Gavilan Drain 8	360	7/25/2007	0.25	45.24	0.05	147.31	0.33	11.71
Gavilan Drain 9	405	7/25/2007	0.21	40.75	0.09	132.07	0.29	9.14
Gavilan Drain 10	450	7/25/2007	0.28	60.14	0.12	111.22	0.24	6.84
Gavilan Drain 1	45	8/31/2007	0.55	47.55	0.61	223.2	0.33	39.27
Gavilan Drain 2	90	8/31/2007	0.55	47.3	0.61	221.93	0.33	40.12
Gavilan Drain 3	135	8/31/2007	0.52	46.62	0.73	219.28	0.33	42.44
Gavilan Drain 4	180	8/31/2007	0.49	45.8	0.64	215.71	0.33	43.12
Gavilan Drain 5	225	8/31/2007	0.52	45.62	0.44	214.81	0.32	44.95
Gavilan Drain 6	270	8/31/2007	0.52	45.46	0.35	214.68	0.31	45.91
Gavilan Drain 7	315	8/31/2007	0.52	45.24	0.67	214.69	0.3	50.27
Gavilan Drain 8	360	8/31/2007	0.27	52.73	0.2	213.72	0.19	6.53
Gavilan Drain 9	405	8/31/2007	0.27	56.08	0.12	220.5	0.19	3.06
Gavilan Drain 10	450	8/31/2007	0.23	60.35	2.1	211.93	0.2	3.01

Table 12. Nutrient concentrations in water grab samples from Tick Creek (Site A) 2006.

Location	Area	Date	NH3-N	P	NO3&NO2-N
NA	NA	mm/dd/yyyy	mg/L	mg/L	mg/L
Tick Creek	Above Buffer Strip	2/27/2006	0.0086	0.0384	4.0650
Tick Creek	Below Buffer Strip	2/27/2006	0.0018	0.0273	4.3100

Table 13. Results of KCL extractions for soil core samples at Tick Creek (Site A) and Gavilan Drain (Site B) for 2006-2007.

Site	Date	Sample	Depth	Transect	% Moisture	Ammonium-N	Nitrate-N	Area
Site B	May-07	3	24" - 36"	D	14.75559238	0.208687868	0.538802	Buffer
Site B	May-07	6	24" - 36"	B	15.27426548	0.210439465	0.666575	Cropped
Site B	May-07	5	24" - 36"	D	13.89400074	0.120823027	0.762545	Buffer
Site B	May-07	5	24" - 36"	B	15.17697678	0.269251305	0.798627	Buffer
Site B	May-07	6	24" - 36"	C	14.79001037	0.234714264	0.879352	Cropped
Site B	May-07	4	24" - 36"	D	17.59457708	0.347974328	0.915955	Buffer
Site B	May-07	3	24" - 36"	C	16.2421541	0.218166492	0.937141	Buffer
Site B	May-07	2	24" - 36"	C	11.4250052	0.204222481	0.966436	Creekside
Site B	May-07	5	24" - 36"	E	14.17308645	0.163226382	1.003998	Buffer
Site B	May-07	3	24" - 36"	B	15.60235198	0.291446091	1.006183	Buffer
Site B	May-07	6	24" - 36"	F	14.51866062	0.26347264	1.061618	Cropped
Site B	May-07	6	24" - 36"	D	15.73888484	0.164640978	1.082182	Cropped
Site B	May-07	5	24" - 36"	C	16.21531954	0.241985248	1.120523	Buffer
Site B	May-07	1	24" - 36"	G	14.75319617	0.267812841	1.124092	Creekside
Site B	May-07	6	24" - 36"	E	14.77853313	3.584670152	1.317455	Cropped
Site B	May-07	2	24" - 36"	G	12.67287479	0.418429123	1.882708	Creekside
Site B	May-07	5	24" - 36"	G	11.43569035	0.426449893	1.917854	Buffer
Site B	May-07	1	24" - 36"	F	15.96111391	0.282887911	1.948739	Creekside
Site B	May-07	5	24" - 36"	F	15.00815661	0.177463574	2.074283	Buffer
Site B	May-07	2	24" - 36"	F	13.92382718	0.453048204	2.265454	Creekside
Site B	May-07	3	24" - 36"	G	11.10841424	0.339426322	2.355149	Buffer
Site B	May-07	3	24" - 36"	E	15.07403014	0.23675522	2.401455	Buffer
Site B	May-07	4	24" - 36"	C	17.96404228	0.239709574	2.533294	Buffer
Site B	May-07	4	24" - 36"	E	16.54199819	0.252626991	2.608607	Buffer
Site B	May-07	1	24" - 36"	E	16.6123637	0.093944717	2.965304	Creekside
Site B	May-07	1	24" - 36"	C	10.6311971	0.236486572	3.511028	Creekside
Site B	May-07	2	24" - 36"	B	13.29568297	0.304528561	4.018584	Creekside
Site B	May-07	2	24" - 36"	E	7.566093548	0.354122427	4.119086	Creekside
Site B	May-07	4	24" - 36"	B	18.13953488	0.342484537	4.798547	Buffer

Site B	May-07	1	24" - 36"	B	9.570143574	0.345594785	5.030398	Creekside
Site B	May-07	2	24" - 36"	D	12.03115854	0.476661785	5.29239	Creekside
Site B	May-07	4	24" - 36"	G	14.12729758	1.467993932	7.112828	Buffer
Site B	May-07	1	24" - 36"	D	13.29694421	0.14183234	7.637126	Creekside
Site B	May-07	3	24" - 36"	F	13.86005561	0.351168475	8.19381	Buffer
Site B	May-07	4	24" - 36"	F	12.61776726	3.042388193	12.57364	Buffer
Site B	May-07	6	24" - 36"	G	11.06299213	0.353509843	41.74946	Cropped
Site B	May-07	3	0" - 12"	F	6.809745275	0.064789348	0.63035	Buffer
Site B	May-07	1	0" - 12"	G	4.88252149	0.178107922	0.687996	Creekside
Site B	May-07	1	0" - 12"	E	7.328605201	0.085414631	0.846849	Creekside
Site B	May-07	2	0" - 12"	G	7.205578512	0.295645928	0.880387	Creekside
Site B	May-07	3	0" - 12"	G	7.635521459	0.222734894	0.975923	Buffer
Site B	May-07	6	0" - 12"	G	7.240749201	0.319406493	1.063759	Cropped
Site B	May-07	1	0" - 12"	F	7.195418258	0.248241781	1.119344	Creekside
Site B	May-07	6	0" - 12"	F	9.86272822	0.124699864	1.157665	Cropped
Site B	May-07	1	0" - 12"	C	5.226966724	0.517900164	1.173416	Creekside
Site B	May-07	5	0" - 12"	D	9.359478253	0.416391419	1.246722	Buffer
Site B	May-07	1	0" - 12"	D	6.531522059	0.272078993	1.273799	Creekside
Site B	May-07	6	0" - 12"	D	9.703900541	0.071121769	1.352866	Cropped
Site B	May-07	3	0" - 12"	D	7.304355643	0.284003405	1.385551	Buffer
Site B	May-07	3	0" - 12"	E	8.351432201	0.182152558	1.499621	Buffer
Site B	May-07	1	0" - 12"	B	7.286683725	0.208828463	1.530914	Creekside
Site B	May-07	2	0" - 12"	E	5.583581253	0.256177991	1.621977	Creekside
Site B	May-07	2	0" - 12"	F	6.385178117	0.307127034	1.743738	Creekside
Site B	May-07	5	0" - 12"	B	9.646545584	0.443331109	1.91339	Buffer
Site B	May-07	5	0" - 12"	G	8.603365988	0.237349768	1.92385	Buffer
Site B	May-07	5	0" - 12"	E	7.568130533	0.255318035	2.095847	Buffer
Site B	May-07	4	0" - 12"	G	8.342548225	0.262716074	2.102616	Buffer
Site B	May-07	6	0" - 12"	C	9.604858023	0.341267464	2.107454	Cropped
Site B	May-07	6	0" - 12"	E	9.237054801	0.194333338	2.12199	Cropped

Site B	May-07	2	0" - 12"	C	7.196100917	0.397861268	2.138166	Creekside
Site B	May-07	2	0" - 12"	D	6.45112383	0.982287502	2.260706	Creekside
Site B	May-07	6	0" - 12"	B	9.725591902	0.3442631	2.350127	Cropped
Site B	May-07	3	0" - 12"	B	7.710954152	0.384765896	2.488675	Buffer
Site B	May-07	2	0" - 12"	B	7.358953393	0.850188005	2.726189	Creekside
Site B	May-07	3	0" - 12"	C	8.996417356	0.242488954	2.772032	Buffer
Site B	May-07	4	0" - 12"	F	8.02023985	0.060773018	2.849841	Buffer
Site B	May-07	5	0" - 12"	F	9.012679435	0.430034928	2.940467	Buffer
Site B	May-07	5	0" - 12"	C	9.2051645	0.469324545	3.770181	Buffer
Site B	May-07	4	0" - 12"	B	12.22071497	0.340912295	5.984753	Buffer
Site B	May-07	4	0" - 12"	D	13.10522414	0.455065989	12.18096	Buffer
Site B	May-07	4	0" - 12"	C	13.2905311	0.505213776	13.03989	Buffer
Site B	May-07	4	0" - 12"	E	10.8399546	0.674983756	19.47858	Buffer
Site B	May-07	3	12" - 24"	B	13.80537975	0.294407517	0.311516	Buffer
Site B	May-07	1	12" - 24"	G	7.831404237	0.235315013	0.7933	Creekside
Site B	May-07	6	12" - 24"	G	9.203151335	0.270056243	0.823132	Cropped
Site B	May-07	5	12" - 24"	B	12.26470588	0.195197938	0.825837	Buffer
Site B	May-07	3	12" - 24"	G	8.658918562	0.17892889	0.867306	Buffer
Site B	May-07	3	12" - 24"	D	13.02504306	0.222592809	0.907541	Buffer
Site B	May-07	4	12" - 24"	C	16.56622349	0.136276205	0.994448	Buffer
Site B	May-07	6	12" - 24"	B	12.45576136	0.26194295	0.997169	Cropped
Site B	May-07	2	12" - 24"	D	10.57034221	0.21821596	1.008132	Creekside
Site B	May-07	2	12" - 24"	G	10.29891896	0.316524648	1.071579	Creekside
Site B	May-07	2	12" - 24"	E	11.19457343	0.08688868	1.170021	Creekside
Site B	May-07	1	12" - 24"	E	11.31943798	0.123983664	1.196636	Creekside
Site B	May-07	6	12" - 24"	F	12.46921581	0.192181871	1.271141	Cropped
Site B	May-07	4	12" - 24"	G	9.930482737	0.360610348	1.271555	Buffer
Site B	May-07	4	12" - 24"	D	16.37264435	0.228336334	1.2717	Buffer
Site B	May-07	2	12" - 24"	B	16.82874232	0.306611756	1.301493	Creekside
Site B	May-07	5	12" - 24"	D	13.3584455	0.331155139	1.339064	Buffer

Site B	May-07	5	12" - 24"	E	12.37537928	1.778978918	1.362083	Buffer
Site B	May-07	2	12" - 24"	F	9.958658705	0.052469337	1.366699	Creekside
Site B	May-07	6	12" - 24"	D	13.60547259	0.278524495	1.413885	Cropped
Site B	May-07	6	12" - 24"	C	13.23749377	0.364397035	1.423656	Cropped
Site B	May-07	3	12" - 24"	F	9.705008004	0.233900015	1.457282	Buffer
Site B	May-07	6	12" - 24"	E	13.7069944	0.494184063	1.774046	Cropped
Site B	May-07	1	12" - 24"	C	8.546280522	0.18535606	1.818207	Creekside
Site B	May-07	5	12" - 24"	C	14.43745751	0.463545858	1.974216	Buffer
Site B	May-07	1	12" - 24"	D	8.795001748	0.345869908	2.051691	Creekside
Site B	May-07	1	12" - 24"	B	9.636575775	0.293685878	2.166253	Creekside
Site B	May-07	4	12" - 24"	F	12.87484288	0.219663159	2.250751	Buffer
Site B	May-07	2	12" - 24"	C	16.50780937	0.202452776	2.882248	Creekside
Site B	May-07	4	12" - 24"	E	14.44555173	0.130682408	2.899933	Buffer
Site B	May-07	5	12" - 24"	G	8.842971589	0.330170454	2.928408	Buffer
Site B	May-07	5	12" - 24"	F	14.23705386	0.832585188	3.541205	Buffer
Site B	May-07	4	12" - 24"	B	17.11901705	0.292541823	4.855897	Buffer
Site B	May-07	3	12" - 24"	E	9.978730946	NA	NA	Buffer
Site B	May-07	1	12" - 24"	F	10.46328671	NA	NA	Creekside
Site B	May-07	3	12" - 24"	C	13.15875157	NA	NA	Buffer
Site A	May-07	3	24" - 36"	F	9.937198068	0.266906386	7.823118	Buffer
Site A	May-07	4	24" - 36"	F	8.199056789	0.370919783	8.800915	Cropped
Site A	May-07	3	24" - 36"	G	11.42018041	0.452315288	9.076112	Buffer
Site A	May-07	3	24" - 36"	E	12.14681156	0.394032646	10.35225	Buffer
Site A	May-07	5	24" - 36"	E	13.78367291	0.398915346	13.56312	Cropped
Site A	May-07	4	24" - 36"	G	9.313889353	0.271903881	14.81727	Cropped
Site A	May-07	2	24" - 36"	E	13.15692156	0.160159466	15.45239	Buffer
Site A	May-07	1	24" - 36"	G	11.36278896	0.112553977	16.91849	Creekside
Site A	May-07	5	24" - 36"	F	15.50153505	0.252813209	22.32401	Cropped
Site A	May-07	2	24" - 36"	G	15.39211438	0.324819889	31.23067	Buffer
Site A	May-07	5	24" - 36"	G	14.72872126	-0.069035775	32.72046	Cropped

Site A	May-07	1	24" - 36"	E	10.57622174	0.209746363	37.4962	Creekside
Site A	May-07	1	24" - 36"	F	14.07457346	0.598478977	38.35231	Creekside
Site A	May-07	2	24" - 36"	F	10.18872041	0.244449415	38.416	Buffer
Site A	May-07	4	24" - 36"	E	NA	NA	NA	Cropped
Site A	May-07	2	0" - 12"	G	8.013315322	-0.172773736	12.84728	Buffer
Site A	May-07	3	0" - 12"	F	8.342046643	0.209322223	4.175873	Buffer
Site A	May-07	3	0" - 12"	E	8.786462039	0.134915998	5.124632	Buffer
Site A	May-07	4	0" - 12"	F	9.24951055	0.411636719	7.840699	Cropped
Site A	May-07	3	0" - 12"	G	7.646301067	0.283336209	7.988334	Buffer
Site A	May-07	4	0" - 12"	E	6.899266564	0.957516587	15.42027	Cropped
Site A	May-07	1	0" - 12"	G	8.852605137	1.222611552	16.43733	Creekside
Site A	May-07	2	0" - 12"	F	8.440766088	0.107474804	20.23795	Buffer
Site A	May-07	5	0" - 12"	E	10.70418802	0.336031866	20.53916	Cropped
Site A	May-07	2	0" - 12"	E	9.316011045	0.189634409	20.57549	Buffer
Site A	May-07	5	0" - 12"	F	9.453400744	0.097656276	23.43751	Cropped
Site A	May-07	1	0" - 12"	F	8.683593937	0.242241311	28.59011	Creekside
Site A	May-07	4	0" - 12"	G	7.786120809	0.21750623	29.50332	Cropped
Site A	May-07	5	0" - 12"	G	8.933688088	0.029536887	31.09429	Cropped
Site A	May-07	1	0" - 12"	E	9.703397289	NA	NA	Creekside
Site A	May-07	3	12" - 24"	F	9.353548323	2.157873992	3.637366	Buffer
Site A	May-07	4	12" - 24"	F	9.692451072	0.245605412	4.956968	Cropped
Site A	May-07	4	12" - 24"	E	11.02035841	0.505121699	7.372358	Cropped
Site A	May-07	3	12" - 24"	G	8.36292082	0.182513138	7.707726	Buffer
Site A	May-07	3	12" - 24"	E	11.32113821	0.262002423	9.335719	Buffer
Site A	May-07	2	12" - 24"	E	10.98066298	0.823042832	14.56118	Buffer
Site A	May-07	1	12" - 24"	G	10.84934277	0.499343025	21.53599	Creekside
Site A	May-07	5	12" - 24"	E	13.7264041	0.249669178	23.35389	Cropped
Site A	May-07	5	12" - 24"	F	13.95504691	0.112851582	25.65794	Cropped
Site A	May-07	2	12" - 24"	G	9.767461927	0.158863434	26.69139	Buffer
Site A	May-07	5	12" - 24"	G	12.26696495	0.182256633	26.97972	Cropped

Site A	May-07	4	12" - 24"	G	11.03752759	0.044650987	33.4147	Cropped
Site A	May-07	1	12" - 24"	E	11.48934031	0.249039644	33.76429	Creekside
Site A	May-07	2	12" - 24"	F	10.28961749	0.244139894	43.90371	Buffer
Site A	May-07	1	12" - 24"	F	9.980419885	0.421054077	54.2257	Creekside
Site B	May-07	5	24" - 36"	A	16.17657843	0.298380484	0.867383	Buffer
Site B	May-07	6	24" - 36"	A	16.62601006	0.224012382	0.882915	Cropped
Site B	May-07	3	24" - 36"	A	15.10004653	7.09332733	1.120348	Buffer
Site B	May-07	2	24" - 36"	A	17.48335156	0.197029558	2.648309	Creekside
Site B	May-07	4	24" - 36"	A	19.34843219	0.556068064	4.03407	Buffer
Site B	May-07	1	24" - 36"	A	19.5492198	0.341714249	8.521969	Creekside
Site B	May-07	1	0" - 12"	A	7.578102789	0.32279818	1.142209	Creekside
Site B	May-07	2	0" - 12"	A	7.301980198	0.593139077	1.53988	Creekside
Site B	May-07	5	0" - 12"	A	9.334174584	9.401861084	2.12779	Buffer
Site B	May-07	3	0" - 12"	A	7.35629058	1.012290894	2.393704	Buffer
Site B	May-07	6	0" - 12"	A	11.39549998	5.95608724	2.646398	Cropped
Site B	May-07	4	0" - 12"	A	9.872611465	0.537324711	5.850305	Buffer
Site B	May-07	2	12" - 24"	A	11.52781405	0.25322375	0.84617	Creekside
Site B	May-07	6	12" - 24"	A	13.3119837	0.307861128	1.427568	Cropped
Site B	May-07	3	12" - 24"	A	12.63501022	0.713486187	1.809819	Buffer
Site B	May-07	1	12" - 24"	A	13.7524144	0.367189271	2.428127	Creekside
Site B	May-07	5	12" - 24"	A	14.1996153	0.436801925	2.675013	Buffer
Site B	May-07	4	12" - 24"	A	15.3474835	NA	NA	Buffer
Site A	May-07	2	24" - 36"	A	13.33022726	0.537338122	4.841371	Buffer
Site A	May-07	3	24" - 36"	A	11.80988958	0.521192343	6.812753	Buffer
Site A	May-07	1	24" - 36"	A	14.17347704	0.698497622	7.434588	Creekside
Site A	May-07	1	24" - 36"	B	4.764073602	0.550491671	9.068135	Creekside
Site A	May-07	5	24" - 36"	D	13.04707573	0.366512039	12.73037	Cropped
Site A	May-07	2	24" - 36"	B	15.5898825	0.524744979	16.74308	Buffer
Site A	May-07	1	24" - 36"	C	14.36904254	1.019449268	19.37825	Creekside
Site A	May-07	3	24" - 36"	B	12.12053869	0.747491491	22.76613	Buffer

Site A	May-07	4	24" - 36"	B	17.13568567	0.643214064	23.21845	Buffer
Site A	May-07	2	24" - 36"	C	12.72166203	0.486569306	24.1076	Buffer
Site A	May-07	4	24" - 36"	A	15.98794023	0.813829196	28.96944	Buffer
Site A	May-07	2	24" - 36"	D	13.45890553	0.66962766	31.92834	Buffer
Site A	May-07	4	24" - 36"	D	13.38553662	1.136123953	47.2421	Cropped
Site A	May-07	3	24" - 36"	C	15.08439848	0.618310648	48.35594	Buffer
Site A	May-07	5	24" - 36"	B	9.419396344	0.636219864	53.33504	Cropped
Site A	May-07	1	24" - 36"	D	12.4901149	0.564561313	56.77907	Creekside
Site A	May-07	5	24" - 36"	A	16.35552619	0.961275763	65.63216	Cropped
Site A	May-07	5	24" - 36"	C	14.8995624	0.774953195	70.11164	Cropped
Site A	May-07	3	24" - 36"	D	9.91637884	NA	NA	Buffer
Site A	May-07	4	24" - 36"	C	15.6988743	NA	NA	Cropped
Site A	May-07	2	0" - 12"	C	8.272731094	1.825034996	10.08114	Buffer
Site A	May-07	2	0" - 12"	D	8.809473462	0.685476474	10.42857	Buffer
Site A	May-07	2	0" - 12"	A	13.8634208	0.579621097	11.5753	Buffer
Site A	May-07	3	0" - 12"	D	8.11319024	0.6100311	13.33973	Buffer
Site A	May-07	3	0" - 12"	A	9.732501115	0.935171412	13.73383	Buffer
Site A	May-07	3	0" - 12"	B	7.577025788	1.026040995	14.51535	Buffer
Site A	May-07	3	0" - 12"	C	8.556550719	0.946452164	18.86114	Buffer
Site A	May-07	5	0" - 12"	D	10.16023173	0.523975892	25.19758	Cropped
Site A	May-07	5	0" - 12"	A	9.859043708	0.445464979	27.87487	Cropped
Site A	May-07	1	0" - 12"	A	8.731126325	6.134623381	34.80606	Creekside
Site A	May-07	2	0" - 12"	B	12.93698072	0.629532029	37.85962	Buffer
Site A	May-07	5	0" - 12"	C	9.226799537	0.606110472	43.07805	Cropped
Site A	May-07	1	0" - 12"	C	9.321833088	1.574649347	43.32845	Creekside
Site A	May-07	1	0" - 12"	B	11.54871054	0.848793992	43.40976	Creekside
Site A	May-07	4	0" - 12"	B	8.73318872	2.161896688	44.38595	Buffer
Site A	May-07	4	0" - 12"	A	7.344778624	1.296830346	44.52412	Buffer
Site A	May-07	1	0" - 12"	D	9.901541096	0.912594061	45.19117	Creekside
Site A	May-07	4	0" - 12"	C	7.884288145	0.999477922	59.57526	Cropped

Site A	May-07	4	0" - 12"	D	6.806719352	4.231629193	62.76037	Cropped
Site A	May-07	5	0" - 12"	B	10.1379344	NA	NA	Cropped
Site A	May-07	3	12" - 24"	B	13.17542561	0.634907275	8.864747	Buffer
Site A	May-07	5	12" - 24"	D	14.62014331	0.398263744	10.65601	Cropped
Site A	May-07	3	12" - 24"	A	15.60924993	0.5753855	11.28267	Buffer
Site A	May-07	2	12" - 24"	A	17.41757972	1.083146008	16.06711	Buffer
Site A	May-07	3	12" - 24"	D	10.41907572	0.644949306	16.61488	Buffer
Site A	May-07	1	12" - 24"	A	16.75598428	0.54008841	20.26477	Creekside
Site A	May-07	2	12" - 24"	D	13.38108339	0.620440656	21.85775	Buffer
Site A	May-07	4	12" - 24"	B	13.46400035	0.941837969	24.3339	Buffer
Site A	May-07	1	12" - 24"	B	16.41457015	0.620566578	29.79386	Creekside
Site A	May-07	4	12" - 24"	A	11.47018506	0.524045591	30.062	Buffer
Site A	May-07	3	12" - 24"	C	15.17092972	0.418892841	35.98642	Buffer
Site A	May-07	1	12" - 24"	C	17.25657289	0.794193424	36.17023	Creekside
Site A	May-07	5	12" - 24"	A	11.47831112	1.273253686	41.94992	Cropped
Site A	May-07	4	12" - 24"	D	11.79775281	1.51822352	43.82901	Cropped
Site A	May-07	4	12" - 24"	C	14.24415786	0.52705144	46.86044	Cropped
Site A	May-07	1	12" - 24"	D	14.17309116	1.479698335	51.50595	Creekside
Site A	May-07	5	12" - 24"	C	14.44357475	0.698459978	59.77045	Cropped
Site A	May-07	2	12" - 24"	C	14.11524315	NA	NA	Buffer
Site A	May-07	5	12" - 24"	B	15.16775396	NA	NA	Cropped
Site A	May-07	2	12" - 24"	B	17.756221	NA	NA	Buffer
Site A	Oct-06	3	24" - 36"	3	9.922738979	1.056771942	2.036887	Buffer
Site A	Oct-06	4	24" - 36"	3	9.9083782	0.572199574	5.076658	Buffer
Site A	Oct-06	6	24" - 36"	1	10.67657741	1.533459309	8.151279	Creekside
Site A	Oct-06	5	24" - 36"	1	10.16483516	0.900281971	8.785884	Buffer
Site A	Oct-06	1	24" - 36"	3	10.2607233	1.209360447	9.181267	Cropped
Site A	Oct-06	2	24" - 36"	3	9.702672187	1.623572026	9.90742	Cropped
Site A	Oct-06	6	24" - 36"	2	10.55186923	0.392470361	11.21344	Creekside
Site A	Oct-06	4	24" - 36"	4	13.34072432	0.299837516	12.57383	Buffer

Site A	Oct-06	5	24" - 36"	3	9.843627834	0.527051375	15.03392	Buffer
Site A	Oct-06	5	24" - 36"	2	12.28915663	1.067212838	15.16259	Buffer
Site A	Oct-06	3	24" - 36"	1	10.68278052	0.679521277	18.67346	Buffer
Site A	Oct-06	3	24" - 36"	4	11.94338686	0.710074625	19.06502	Buffer
Site A	Oct-06	5	24" - 36"	4	8.513446626	0.260554239	19.74281	Buffer
Site A	Oct-06	6	24" - 36"	4	9.280081776	0.257860079	20.44296	Creekside
Site A	Oct-06	6	24" - 36"	3	10.10612639	0.574326881	20.61136	Creekside
Site A	Oct-06	2	24" - 36"	4	10.42467743	0.225784496	21.19866	Cropped
Site A	Oct-06	4	24" - 36"	1	10.587531	0.956664119	25.16082	Buffer
Site A	Oct-06	4	24" - 36"	2	14.08606732	2.281584539	25.71126	Buffer
Site A	Oct-06	1	24" - 36"	4	12.02064897	0.385307259	28.10292	Cropped
Site A	Oct-06	2	24" - 36"	1	10.7999069	1.042741067	38.01125	Cropped
Site A	Oct-06	2	24" - 36"	2	13.47292164	2.393965693	42.67228	Cropped
Site A	Oct-06	1	24" - 36"	2	11.60210947	0.80985515	44.40045	Cropped
Site A	Oct-06	1	24" - 36"	1	14.23821794	1.396015425	45.51759	Cropped
Site A	Oct-06	3	24" - 36"	2	11.65064364	1.660251921	48.43719	Buffer
Site A	Oct-06	2	0" - 12"	1	7.161781752	-0.145386632	-0.6496	Cropped
Site A	Oct-06	3	0" - 12"	3	4.204874019	1.843705014	28.15682	Buffer
Site A	Oct-06	4	0" - 12"	3	4.753129079	2.636007106	32.5845	Buffer
Site A	Oct-06	5	0" - 12"	4	5.818673884	0.366482626	34.61225	Buffer
Site A	Oct-06	3	0" - 12"	4	6.81708411	0.327779808	37.28836	Buffer
Site A	Oct-06	4	0" - 12"	2	4.085106383	1.804107223	37.30231	Buffer
Site A	Oct-06	1	0" - 12"	4	7.857035138	0.853531624	40.29036	Cropped
Site A	Oct-06	4	0" - 12"	4	5.007863587	0.406017894	43.48654	Buffer
Site A	Oct-06	6	0" - 12"	4	5.459346121	0.338843465	44.86302	Creekside
Site A	Oct-06	3	0" - 12"	1	4.044961003	2.139159757	46.41175	Buffer
Site A	Oct-06	1	0" - 12"	3	7.628376373	1.013865965	46.86314	Cropped
Site A	Oct-06	3	0" - 12"	2	5.237572526	2.662049098	48.33003	Buffer
Site A	Oct-06	6	0" - 12"	1	6.200586302	2.947973849	50.06808	Creekside
Site A	Oct-06	1	0" - 12"	2	6.698028674	0.192498894	51.1215	Cropped

Site A	**Oct-06**	**4**	**0" - 12"**	**1**	**6.70694864**	**3.095484403**	**52.98135**	**Buffer**
Site A	**Oct-06**	**5**	**0" - 12"**	**3**	**5.706670847**	**1.254401763**	**55.51575**	**Buffer**
Site A	**Oct-06**	**2**	**0" - 12"**	**4**	**6.046980386**	**0.330115889**	**57.20262**	**Cropped**
Site A	**Oct-06**	**1**	**0" - 12"**	**1**	**7.518614438**	**0.556258638**	**57.5179**	**Cropped**
Site A	**Oct-06**	**2**	**0" - 12"**	**3**	**6.502923977**	**1.188166006**	**59.61106**	**Cropped**
Site A	**Oct-06**	**6**	**0" - 12"**	**2**	**7.181525969**	**1.164587537**	**61.05106**	**Creekside**
Site A	**Oct-06**	**5**	**0" - 12"**	**1**	**6.384576865**	**3.712053114**	**61.17241**	**Buffer**
Site A	**Oct-06**	**6**	**0" - 12"**	**3**	**5.474116564**	**2.224636329**	**63.27317**	**Creekside**
Site A	**Oct-06**	**5**	**0" - 12"**	**2**	**5.448128814**	**0.755443235**	**67.76097**	**Buffer**
Site A	**Oct-06**	**2**	**0" - 12"**	**2**	**6.562718175**	**0.618791351**	**76.66786**	**Cropped**
Site A	**Oct-06**	**3**	**12" - 24"**	**3**	**8.812504984**	**1.261264468**	**6.129036**	**Buffer**
Site A	**Oct-06**	**4**	**12" - 24"**	**3**	**8.88225256**	**0.859931029**	**7.50658**	**Buffer**
Site A	**Oct-06**	**6**	**12" - 24"**	**1**	**13.36646388**	**1.158096939**	**8.990489**	**Creekside**
Site A	**Oct-06**	**1**	**12" - 24"**	**3**	**11.53370439**	**0.903141323**	**10.01561**	**Cropped**
Site A	**Oct-06**	**5**	**12" - 24"**	**1**	**13.58356381**	**0.686131563**	**10.92533**	**Buffer**
Site A	**Oct-06**	**3**	**12" - 24"**	**4**	**7.023384859**	**0.255781267**	**18.91104**	**Buffer**
Site A	**Oct-06**	**4**	**12" - 24"**	**4**	**7.671624233**	**0.267539555**	**19.68154**	**Buffer**
Site A	**Oct-06**	**4**	**12" - 24"**	**2**	**7.537525355**	**1.474227032**	**19.69836**	**Buffer**
Site A	**Oct-06**	**5**	**12" - 24"**	**2**	**9.837702871**	**0.588857928**	**20.4671**	**Buffer**
Site A	**Oct-06**	**6**	**12" - 24"**	**2**	**14.54258967**	**0.344796896**	**20.87089**	**Creekside**
Site A	**Oct-06**	**2**	**12" - 24"**	**4**	**8.753519324**	**0.592512085**	**21.63957**	**Cropped**
Site A	**Oct-06**	**1**	**12" - 24"**	**4**	**9.425421625**	**0.42485445**	**23.32634**	**Cropped**
Site A	**Oct-06**	**3**	**12" - 24"**	**1**	**12.05932203**	**0.974310863**	**25.53007**	**Buffer**
Site A	**Oct-06**	**6**	**12" - 24"**	**3**	**7.148536321**	**0.421954624**	**26.52286**	**Creekside**
Site A	**Oct-06**	**2**	**12" - 24"**	**3**	**10.73251029**	**0.903668939**	**27.4309**	**Cropped**
Site A	**Oct-06**	**6**	**12" - 24"**	**4**	**8.247674988**	**0.422293808**	**28.48413**	**Creekside**
Site A	**Oct-06**	**5**	**12" - 24"**	**4**	**7.247874116**	**0.282702893**	**28.76547**	**Buffer**
Site A	**Oct-06**	**3**	**12" - 24"**	**2**	**8.034591195**	**2.000465802**	**31.36769**	**Buffer**
Site A	**Oct-06**	**5**	**12" - 24"**	**3**	**8.476271056**	**0.92690851**	**32.88195**	**Buffer**
Site A	**Oct-06**	**4**	**12" - 24"**	**1**	**10.17429001**	**0.874346696**	**38.58309**	**Buffer**

Site A	Oct-06	1	12" - 24"	2	8.660721459	0.545019188	43.984	Cropped
Site A	Oct-06	2	12" - 24"	1	7.797750964	0.46967231	47.37922	Cropped
Site A	Oct-06	1	12" - 24"	1	9.183365979	1.299016986	47.44457	Cropped
Site A	Oct-06	2	12" - 24"	2	10.25407597	0.722761123	50.86097	Cropped
Site B	Oct-06	3	24" - 36"	1	9.316267012	0.263840066	0.334107	Buffer
Site B	Oct-06	3	24" - 36"	4	12.96126168	0.525459066	0.675832	Buffer
Site B	Oct-06	6	24" - 36"	2	12.5166334	0.830826666	1.061918	Creekside
Site B	Oct-06	4	24" - 36"	6	12.5485979	0.567065159	1.241124	Buffer
Site B	Oct-06	3	24" - 36"	5	11.98578908	0.524967729	1.724894	Buffer
Site B	Oct-06	6	24" - 36"	5	11.68769716	0.568410367	1.960344	Creekside
Site B	Oct-06	4	24" - 36"	4	10	0.147167035	2.476611	Buffer
Site B	Oct-06	3	24" - 36"	6	12.20134342	1.013543574	2.766974	Buffer
Site B	Oct-06	4	24" - 36"	1	8.526165895	0.803173809	2.898565	Buffer
Site B	Oct-06	5	24" - 36"	2	11.77655536	0.270935856	3.522166	Creekside
Site B	Oct-06	6	24" - 36"	6	13.60153257	0.630442592	3.543411	Creekside
Site B	Oct-06	1	24" - 36"	6	11.1517686	0.548647451	3.996726	Cropped
Site B	Oct-06	6	24" - 36"	3	12.85624695	0.636585534	4.044472	Buffer
Site B	Oct-06	1	24" - 36"	5	11.58466056	0.562317743	4.217383	Cropped
Site B	Oct-06	3	24" - 36"	2	9.870522953	0.823831442	5.049289	Buffer
Site B	Oct-06	5	24" - 36"	1	10.14642687	2.054144577	5.762843	Creekside
Site B	Oct-06	6	24" - 36"	1	13.01357939	1.429587018	6.038328	Creekside
Site B	Oct-06	2	24" - 36"	5	11.85375607	0.526815205	6.78079	Cropped
Site B	Oct-06	4	24" - 36"	3	13.95817411	0.523819922	7.76376	Buffer
Site B	Oct-06	1	24" - 36"	2	9.146341463	0.286174497	8.124001	Cropped
Site B	Oct-06	3	24" - 36"	3	10.60026482	0.173066298	8.221785	Buffer
Site B	Oct-06	4	24" - 36"	5	11.632083	0.348820311	8.230054	Buffer
Site B	Oct-06	5	24" - 36"	3	12.91221551	0.385896962	8.432196	Creekside
Site B	Oct-06	2	24" - 36"	6	12.09670554	0.337397074	8.758849	Cropped
Site B	Oct-06	4	24" - 36"	2	13.2783954	0.308768036	8.894552	Buffer
Site B	Oct-06	2	24" - 36"	4	14.19641239	0.916972204	10.25983	Cropped

Site B	Oct-06	1	24" - 36"	4	13.85277995	0.457801365	10.29238	Cropped
Site B	Oct-06	5	24" - 36"	5	9.514118545	0.59888443	10.60736	Creekside
Site B	Oct-06	2	24" - 36"	2	9.5043833	0.291169181	10.6503	Cropped
Site B	Oct-06	6	24" - 36"	4	10.6782312	0.589114627	10.76975	Creekside
Site B	Oct-06	5	24" - 36"	4	10.29248132	0.832050083	10.82732	Creekside
Site B	Oct-06	2	24" - 36"	1	10.66862474	0.75722761	11.29276	Cropped
Site B	Oct-06	2	24" - 36"	3	12.50745556	0.844027961	11.90682	Cropped
Site B	Oct-06	1	24" - 36"	3	12.27501216	0.814610736	12.27206	Cropped
Site B	Oct-06	5	24" - 36"	6	13.96548657	2.168748051	13.02635	Creekside
Site B	Oct-06	1	24" - 36"	1	12.50099976	1.25590132	13.43814	Cropped
Site B	Oct-06	5	0" - 12"	3	8.965370724	0.395005964	1.698118	Creekside
Site B	Oct-06	6	0" - 12"	3	8.790328454	0.551523306	1.988153	Buffer
Site B	Oct-06	3	0" - 12"	3	4.453407968	2.118207538	3.813542	Buffer
Site B	Oct-06	6	0" - 12"	2	5.091631308	1.041867951	5.099394	Creekside
Site B	Oct-06	4	0" - 12"	5	4.595167444	0.536176678	5.724593	Buffer
Site B	Oct-06	6	0" - 12"	1	7.256790903	1.042132558	6.552022	Creekside
Site B	Oct-06	4	0" - 12"	1	4.563366961	1.661926774	6.70602	Buffer
Site B	Oct-06	1	0" - 12"	6	6.28043245	0.088544671	6.715467	Cropped
Site B	Oct-06	3	0" - 12"	2	5.116082735	0.539214571	7.085547	Buffer
Site B	Oct-06	5	0" - 12"	2	4.802021904	0.258852492	7.222938	Creekside
Site B	Oct-06	2	0" - 12"	5	7.566580934	0.275869101	7.287885	Cropped
Site B	Oct-06	3	0" - 12"	4	5.775214389	0.868729394	7.350787	Buffer
Site B	Oct-06	1	0" - 12"	5	5.210183541	1.623613191	7.352211	Cropped
Site B	Oct-06	4	0" - 12"	6	3.354352776	1.333877392	8.460594	Buffer
Site B	Oct-06	2	0" - 12"	4	9.518554283	-0.012096905	9.564995	Cropped
Site B	Oct-06	1	0" - 12"	2	7.190327488	0.38510311	9.64902	Cropped
Site B	Oct-06	4	0" - 12"	4	3.919401462	1.225781166	10.27713	Buffer
Site B	Oct-06	3	0" - 12"	6	5.968512571	0.474565401	10.45419	Buffer
Site B	Oct-06	1	0" - 12"	4	5.720141606	0.27621017	10.49267	Cropped
Site B	Oct-06	3	0" - 12"	1	3.638377641	2.660835639	12.14936	Buffer

Site B	**Oct-06**	**2**	**0" - 12"**	**2**	**7.959928555**	**0.831781095**	**12.30445**	**Cropped**
Site B	**Oct-06**	**1**	**0" - 12"**	**3**	**7.000311818**	**0.404302431**	**12.54107**	**Cropped**
Site B	**Oct-06**	**1**	**0" - 12"**	**1**	**8.029755284**	**0.7164921**	**12.73764**	**Cropped**
Site B	**Oct-06**	**6**	**0" - 12"**	**6**	**5.657504608**	**0.273934045**	**14.1329**	**Creekside**
Site B	**Oct-06**	**2**	**0" - 12"**	**6**	**7.690449348**	**0.544041911**	**14.17372**	**Cropped**
Site B	**Oct-06**	**6**	**0" - 12"**	**5**	**7.007575758**	**0.237881874**	**15.15275**	**Creekside**
Site B	**Oct-06**	**4**	**0" - 12"**	**3**	**6.841276657**	**0.450093292**	**15.9676**	**Buffer**
Site B	**Oct-06**	**3**	**0" - 12"**	**5**	**5.36234367**	**1.414758917**	**17.01237**	**Buffer**
Site B	**Oct-06**	**2**	**0" - 12"**	**3**	**8.7250934**	**0.205475586**	**18.48723**	**Cropped**
Site B	**Oct-06**	**6**	**0" - 12"**	**4**	**3.881350584**	**0.772854329**	**19.26191**	**Creekside**
Site B	**Oct-06**	**5**	**0" - 12"**	**4**	**7.104968248**	**0.317624128**	**19.76965**	**Creekside**
Site B	**Oct-06**	**4**	**0" - 12"**	**2**	**7.045847395**	**0.274959566**	**19.86702**	**Buffer**
Site B	**Oct-06**	**5**	**0" - 12"**	**1**	**6.019967218**	**0.74682178**	**22.73511**	**Creekside**
Site B	**Oct-06**	**5**	**0" - 12"**	**6**	**7.256060995**	**0.171077361**	**24.17593**	**Creekside**
Site B	**Oct-06**	**2**	**0" - 12"**	**1**	**8.084596967**	**0.527062606**	**25.89017**	**Cropped**
Site B	**Oct-06**	**5**	**0" - 12"**	**5**	**6.80970859**	**0.240206752**	**29.36359**	**Creekside**
Site B	**Oct-06**	**4**	**12" - 24"**	**4**	**8.804036753**	**0.213805603**	**0.915748**	**Buffer**
Site B	**Oct-06**	**6**	**12" - 24"**	**2**	**10.16376053**	**0.601580923**	**0.961682**	**Creekside**
Site B	**Oct-06**	**6**	**12" - 24"**	**3**	**11.13220003**	**0.79571594**	**1.092911**	**Buffer**
Site B	**Oct-06**	**5**	**12" - 24"**	**2**	**7.753553092**	**0.246122332**	**1.303286**	**Creekside**
Site B	**Oct-06**	**3**	**12" - 24"**	**5**	**8.265051657**	**0.538030751**	**1.492451**	**Buffer**
Site B	**Oct-06**	**3**	**12" - 24"**	**4**	**8.269230769**	**0.55894797**	**2.045512**	**Buffer**
Site B	**Oct-06**	**4**	**12" - 24"**	**6**	**8.739990935**	**0.12293115**	**2.359839**	**Buffer**
Site B	**Oct-06**	**4**	**12" - 24"**	**1**	**6.54120378**	**0.856661461**	**2.416053**	**Buffer**
Site B	**Oct-06**	**3**	**12" - 24"**	**2**	**7.451669596**	**0.345155932**	**2.550585**	**Buffer**
Site B	**Oct-06**	**3**	**12" - 24"**	**6**	**9.818705524**	**0.167039405**	**2.595245**	**Buffer**
Site B	**Oct-06**	**5**	**12" - 24"**	**1**	**8.657013713**	**1.201155137**	**2.687787**	**Creekside**
Site B	**Oct-06**	**3**	**12" - 24"**	**1**	**6.997603031**	**0.869425723**	**3.012214**	**Buffer**
Site B	**Oct-06**	**5**	**12" - 24"**	**3**	**11.94546335**	**0.518695658**	**3.055442**	**Creekside**
Site B	**Oct-06**	**6**	**12" - 24"**	**1**	**9.911733744**	**2.062558918**	**3.276725**	**Creekside**

Site B	Oct-06	4	12" - 24"	5	7.331919211	0.250221953	4.328657	Buffer
Site B	Oct-06	1	12" - 24"	5	9.830000881	0.839907893	4.373314	Cropped
Site B	Oct-06	1	12" - 24"	6	11.23143338	0.230683612	5.199346	Cropped
Site B	Oct-06	3	12" - 24"	3	5.835113199	0.460219629	5.376017	Buffer
Site B	Oct-06	6	12" - 24"	5	9.182692308	0.319801137	5.792805	Creekside
Site B	Oct-06	4	12" - 24"	3	11.5163796	0.441241709	6.11529	Buffer
Site B	Oct-06	2	12" - 24"	5	11.94347493	0.650310137	6.358588	Cropped
Site B	Oct-06	6	12" - 24"	6	11.18746767	0.827241222	6.660352	Creekside
Site B	Oct-06	2	12" - 24"	6	12.41608149	0.080188874	7.169204	Cropped
Site B	Oct-06	1	12" - 24"	3	9.824921439	0.154267801	7.195878	Cropped
Site B	Oct-06	2	12" - 24"	4	12.91895658	0.133028474	7.416222	Cropped
Site B	Oct-06	4	12" - 24"	2	9.682445467	0.468788522	7.566411	Buffer
Site B	Oct-06	1	12" - 24"	4	12.05463612	0.633425161	8.763175	Cropped
Site B	Oct-06	2	12" - 24"	1	11.20866064	1.639580958	9.056733	Cropped
Site B	Oct-06	5	12" - 24"	4	8.292258626	0.627307539	9.135955	Creekside
Site B	Oct-06	1	12" - 24"	2	8.336041599	0.184588931	9.250187	Cropped
Site B	Oct-06	6	12" - 24"	4	9.260346346	0.478139839	9.48505	Creekside
Site B	Oct-06	5	12" - 24"	5	9.023546847	0.779383953	10.5471	Creekside
Site B	Oct-06	2	12" - 24"	2	8.000346711	0.43420761	11.5904	Cropped
Site B	Oct-06	5	12" - 24"	6	12.76695246	0.701795874	12.18909	Creekside
Site B	Oct-06	2	12" - 24"	3	10.54934698	0.353604689	13.49138	Cropped
Site B	Oct-06	1	12" - 24"	1	10.7428115	1.620075463	16.0842	Cropped